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ORIGINAL ARTICLES.

On the Fossil Flora of the Bristol and Somerset Coalfield.

PART II.

By Robert Crookall, Ph.D.

(PLATES XVI–XVIII.)

THE present paper is a continuation of that published in the Geological Magazine, Vol. LXII, No. IV, April, 1925, pp. 145–80.

I. Additional Records.

In recording the additional species of plants from the Bristol and Somerset Coalfield, the following abbreviations for localities are used :—

CL = Clandown, near Radstock ; BR = Braysdown, near Radstock ; DK = Dunkerton, near Radstock ; K = Kilmersdon, near Radstock ; CM = Camerton, 2 miles north of Radstock ; R = Radstock, Somersetshire ; OM = Old Mills Pit, Farrington Gurney, 7½ miles north of Shepton Mallet, Somersetshire ; ML = Marsh Lane Pit, Farrington Gurney ; BS = Bishop Sutton New Pit, Bishop Sutton, Somersetshire ; MN = Norton Hill Pit, Midsomer Norton, near Radstock ; F = Foxcote Pit, near Radstock ; FP = Parkfield Pit, near Pucklechurch, Gloucestershire ; FC = Coalpit Heath Pit, Gloucestershire ; P = Broad Oak Colliery, Pensford, 2 miles north of Clutton, Somersetshire ; B = Bromley Colliery, 1 mile west of Pensford, Somersetshire ; D = Deep Pit, Kingswood, Bristol ; S = Speedwell Pit, Kingswood, Bristol ; NR = South Liberty Colliery, Bedminster, Bristol ; M = Mells Colliery, Somersetshire ; NB = Newbury Colliery, Somersetshire ; H = Hanham Pit, Hanham, near Bristol.

Where known, the horizon of the specimen is given after the reference to locality, and, following this, a number indicating the frequency with which the plant occurs at that locality, thus

8–10 = very common.
6–7 = fairly common.
3–4 = fairly rare.
1–2 = very rare.

Pteridospermae and Filicales.

Sphenopteris neuropteroides Boul. sp.	CL (3) ; ML, 21 in. seam (1) ; NR (1).
,, *macilenta* L. & H. .	CL (1) ; R (1).
,, sp.	ML, 21 in. seam (1) ; BS (1).
,, ? *sauveuri* Crépin .	B (1).

PTERIDOSPERMAE AND FILICALES.	
Corynepteris sternbergii Ett. sp.	? BS (1).
Renaultia sp.	B (1).
? *Oligocarpia brongniarti* Stur.	FP (1).
Rhodea sp.	D (1).
Alloiopteris sp.	FP (1).
Crossotheca pinnatifida Gut. sp.	FP (1).
,, *crepini* Zeiller	FP (1).
Radstockia sphenopteroides Kidst. sp.	FP (1).
Alethopteris serlii Brongt. sp.	CL (7) ; K (6) ; BR (8) ; DK (7) ; CM (6).
,, cf. *costei* Zeiller	FP (2).
,, *grandini* Brongt. sp.	OM (2) ; R (1).
,, *aquilina* Schl. sp.	P (1).
,, *aquilina* Brongt. sp.	R (1).
Pecopteris crenulata Brongt.	R, Middle Vein (1) ; OM (2) ; ML, 21 in. seam (1).
,, *polymorpha* Brongt.	CL (4) ; K (4) ; F (3) ; BR (5).
,, *arborescens* Schl. sp.	OM (3) ; NR (1) ; K (3) ; BR (3) ; CM (2).
,, *unita* Brongt.	OM (2) ; K (3) ; F (3) ; BR (2).
,, *miltoni* Artis sp.	BS (2) ; NR (1) ; K (4) ; F (5) ; BR (5) ; CM (6).
,, *bucklandii* Brongt.	OM (1) ; BS (1) ; ML, 21 in. seam (1).
,, *cyathea* Schl. sp.	ML, 21 in. seam (2).
Dicksoniites pluckenetii Schl. sp.	BS (1).
Dactylotheca plumosa Art. sp.	F (3) ; BR (4) ; R (4).
Mariopteris muricata Schl. sp.	F (2) ; CL (2).
,, *muricata* (Schl.) forma *nervosa* Bgt.	ML, 21 in. seam (1) ; NR (1).
,, sp.	B (1) ; FP (1).
Neuropteris ovata Hoffm.	OM (3).
,, *rarinervis* Bunb.	OM (3) ; F (3).
,, *scheuchzeri* Hoffm.	K (8) ; F (8) ; BR (7) ; CL (6) ; CM (5).
,, *fimbriata* Lesqx.	R (1) ; ML (1).
,, *macrophylla* Brongt.	ML (1) ; K (7) ; F (6) ; BR (5) ; CL (6) ; CN (5) ; R (4).
,, sp.	FP (1).
,, *flexuosa* Sternb.	K (5) ; F (6) ; BR (5) ; DK (6) ; CL (6) ; CM (5).
,, *heterophylla* Brongt.	B, No. 5 seam (1).
,, *obliqua* Brongt.	D (2).
,, *pseudogigantea* Potonié	NB (1).
Dictyopteris obliqua Bunb.	BS (1).
,, *munsteri* Eichw. sp.	M (1).
Cyclopteris sp.	ML, 21 in. seam (1) ; H (1) ; F (3) ; CM (3).
,, *orbicularis* Brongt.	FC (1).
Rhacophyllum spinosum Lesqx.	FP (1).
,, *goldenbergii* Weiss	FC (1).
Aphlebia crispa Gut.	BS (1) ; ML, 21 in. seam (1).
Odontopteris lindleyana Sternb.	ML, 21 in seam (1).
Caulopteris anglica Kidst.	R (1).
Spiropteris sp.	K (1).
SEMINAAE INCERT SEDIS.	
Trigonocarpus parkinsoni Brongt.	ML (1).
Carpolithus sp.	D (1).
? *Radiospermum grande* Arber	BS (1).

SEMINA INCERTAE SEDIS.	
Radiospermum sp.	D (1).
,, *perpusillum* Lesqx. sp.	BS (1); P (1).
Holcospermum sp.	D (1).
? *Whittleseya* sp.	ML (1).
Samaropsis sp.	NB (1); D (1).
LYCOPODIALES.	
Sigillaria cumulata Weiss	K (2).
,, *tessellata*, Stein sp.	ML, Inferior Seam (1); NR (1); K (1).
,, *rugosa* Brongt.	NR (1).
,, *ovata* Sauv.	ML (1); F (1); ? BR (1).
,, sp.	BR (2); DK (3).
Sigillariophyllum bicarinatum L. & H. sp.	R (3); CL (2); H (1); K (4); F (6); BR (5); DK (3); CL (3); CM (4).
Lepidodendron lanceolatum Lesqx.	? OM (1); ML, Inferior Seam (1); NR (1); F (3); BR (3); CM (3); R (2).
,, *wortheni* Lesqx.	OM (3); NR (1); K (3).
,, *simile* Kidst	D (1); S (1); M (1).
,, *aculeatum* Sternb.	ML (1); K (3); F (4); CM (3).
,, *loricatum* Arber (pars)	ML, Inferior Seam (1); OM (1).
,, sp.	B (1).
Lepidophloios laricinus Sternb.	ML (1); OM (1).
Lepidostrobus lanceolatus L. & H. sp.	CL (2).
,, *majus* Brongt. sp.	P (1); NR (1); BR (1).
,, *radians* Schimp.	S (1).
,, *minor* Goode	BS (1); CM (1).
,, sp.	BS (1); K (2).
Stigmaria ficoides Sternb. sp.	K (3); F (5); BR (4); DK (3); CL (3); CM (4).
,, ? *minuta* Göpp.	FC (1).
Bark of unknown *Lycopod*	D (1).
EQUISETALES.	
Calamites suckowii Brongt.	K (2); F (2); BR (1).
,, sp.	ML, Inferior Seam (1); NR (1); CL (1); CM (2); R (1).
Annularia stellata Schl. sp.	R, Middle Vein (6); K (6); F (4); BR (7); CM (6).
,, *sphenophylloides* Zenk. sp.	R (6); K (5); F (6).
,, ? *microphylla* Sauv.	NR (1).
Asterophyllites charaeformis Sternb. sp.	D (1).
,, *longifolius* Sternb. sp.	FP (1).
Palaeostachya pedunculata Will.	D (1).
Pinnularia capillacea L. & H. sp.	NR (1); BR (3); DK (3); CL (4); CM (3).
SPHENOPHYLLALES.	
Sphenophyllum emarginatum Brongt.	NR (1); K (6); BR (6); CL (7); CM (6).
,, *fasciculatum* Lesqx.	B (1).
,, *cuneifolium* Sternb.	FP (1); ? B, No. 4 Seam (1).
,, *majus* Bronn	ML, 21 in. Seam (3); ? B (1).
,, ? *oblongifolium* Germ. sp.	B (1); FC (1).
CORDAITALES.	
Cordaites sp.	OM (1); K (4); F (5); BR (4); DK (6); CM (5).
Cordaicarpus ovoideus (Berg.)	P (2); D (1).

II. References, Descriptions, and Remarks.

PTERIDOSPERMAE AND FILICALES.

Sphenopteris Brongniart.

1. *Sphenopteris ? sauveuri* Crépin.

Zeiller, 38[1], p. 79, pl. ix, fig. 6.—Potonié, 31, No. 4, figs. 1–3.—Gothan, 15, p. 28, pl. vi, fig. 1.—Kidston, 28, p. 49, pl. v, fig. 5, pl. viii, fig. 4.

Remarks.—This species being very variable, the single fragment collected is difficult to identify. The rachis is slightly flexuous, the pinnules point forward, and the veins are indistinct, as is usual in *S. sauveuri*.

2. *Sphenopteris* sp. (Pl. XVIII, Fig. 4.)

Description.—Ultimate pinnae alternate, up to 3 cm. long, leaving the longitudinally grooved rachis at an angle of about 40 degrees, directed forward. Pinnules leave rachis at an angle of about 30 degrees, up to 8 mm. long by 2 mm. broad, lanceolate, divided into rounded lobes which are directed forward : lowest pinnules bear 6 pairs of lobes, uppermost 2–4 pairs.

Remarks.—The specimen, which was collected at Bishop Sutton New Pit, bears some general resemblance to *Urnatopteris tenella* (Brongt.),[2] but the lobes on the pinnules are not so pronounced and are more numerous than in that species.

Rhodea Presl.

Rhodea sp.

Description.—Rachis smooth. Ultimate pinnae lanceolate, directed forward, leaving the rachis at an angle of about 50 degrees. Pinnules alternate, 2–5 mm. long by 2–3 mm. broad, divided into 2–4 linear spreading segments, into each of which a single vein enters.

Remarks.—The specimens, which are fragmentary, were collected at Deep Pit. They differ from *R. sparsa* Kidst. (28, p. 237, pl. lvi, fig. 3, pl. lix, figs. 5, 6) and from *R. goepperti* Ett. sp. (Kidst., 28, p. 233, pl. lvii, fig. 1) in that both the pinnae and the pinnules leave the rachis at a more acute angle. The pinnules are smaller than in *R. goepperti*, and not so scattered as in *R. sparsa*. On the other hand, there is some similarity to *Sphenopteris schaumburg-lippeana* Stur sp., as figured by Kidston (24, pl. iii, figs. 1, 2).

Renaultia Zeiller.

Renaultia sp.

Remarks.—In general appearance this specimen, collected at Bromley Colliery, is reminiscent of *R. germanica* Potonié sp., as figured by Kidston (28, pt. 4, p. 324, pl. lxxxi, figs. 1, 1*a*), but it is not sufficiently well preserved for specific determination.

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[1] The serial numbers following an author's name refer to the list of works cited on p. 408.

[2] Brongniart, 9, p. 186, pl. xlix, fig. 1. Kidston, 21, pl. xxix, figs. 1–3 ; 28, pt. iv, p. 356, pl. lxxxiii, figs. 1–5, pl. lxxxiv, figs. 1–3.

RADSTOCKIA Kidston.

Radstockia sphenopteroides Kidston sp.

Kidston, 28, pt. 4, p. 373, pl. lxxv, figs. 3, 3*a*.

Remarks.—The specimens here recorded are the only ones known other than the type specimen.

OLIGOCARPIA Göppert.

(?) *Oligocarpia brongniarti* Stur. (Pl. XVI, Fig. 8.)

Zeiller, 38, p. 97, pl. xi, figs. 3–5.—Renier, 32, pl. lxi.—Kidston 28, pt. 4, p. 289, pl. lxix, figs. 2, 2*a*, 3, 3*a* ; text-fig. 19, p. 285.

Remarks.—This very rare species has not previously been met with outside the Yorkian Series, and, if correctly determined, this is the first record of the plant from the Staffordian Series.

CROSSOTHECA Zeiller.

1. *Crossotheca pinnatafida* Gut. sp.

Kidston, 28, pt. 4, p. 346, pl. xc, figs. 1–5, text-fig. 28.

Remarks.—A single well-preserved pinnule of this species was collected at Parkfield Pit. The plant is very rare, and this is the first record from the Staffordian Series.

2. *Crossotheca crepini* Zeiller.

Zeiller, 38, p. 112, pl. xiii, figs. 1–3, text-fig. 21, p. 33.—Renier, 32, pl. lxviii.—Kidston, 28, pt. 4, p. 344, pl. lxxxvii, figs. 1, 2, text-fig. 27.

Remarks.—This rare species has not been recorded previously from outside the Yorkian Series.

NEUROPTERIS Brongniart.

1. *Neuropteris obliqua* (Brongt.).

Zeiller, 38, p. 284, pl. xlviii, figs. 1, 2, 4–7.—Arber, 7, p. 355, pl. lxi, figs. 1–3.

Remarks.—Some of the specimens are typical examples of Brongniart's species, while others are of the form *N. impar* Weiss, as figured by Kidston (24, p. 83, pl. viii, figs. 1–3). These two "species", provisionally kept apart by Kidston, were regarded by Arber (loc. cit.) as representing the upper and lower pinnules respectively of the same plant.

2. *Neuropteris* sp.

Remarks.—The single specimen, collected at Parkfield Colliery, resembles *N. crenulata* Brongt.,[1] in the flexuous rachis, the articulation of the pinnules, the small terminal pinnule, the crenulated margins, and in the venation. It is possibly a terminal pinna of Brongniart's species.

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[1] Brongniart, 9, i, p. 234, pl. lxiv, fig. 2. Zeiller, 40, p. 98, pl. xxvi, fig. 1. Kidston, 18, p. 327, pl. i, fig. 2.

3. *Neuropteris* sp.

Description.—Pinnules 25 mm. long by 12 mm. broad at the base (the broadest part). Veins almost straight, dichotomizing two or three times, leaving the central vein at an angle of about 25 degrees.

Remarks.—This plant, collected at Parkfield Pit, does not agree with any known species of *Neuropteris*, but the preservation is poor. The pinnules are smaller and the veins much further apart than in *N. cordata* Brongt. (9, 1, p. 229, pl. lxiv, fig. 5).

DICTYOPTERIS Gutbier.

Dictyopteris obliqua Bunbury.

Bunbury, 10, p. 427, pl. xxi, fig. 2.—Kidston, 17, p. 76, fig. 3.—*D. sub-brongniarti* Zeiller, 38, p. 290, pl. xlix, fig. 6, pl. l, figs. 1, 2.

Remarks.—Most of the specimens collected consist of isolated pinnules. *D. obliqua* has been recorded once only from outside the Yorkian Series.

ALETHOPTERIS Sternberg.

Alethopteris cf. *costei* Zeiller.

Zeiller, 40, p. 75, pls. xv and xvi.—Potonié, 31, ix, No. 174.

Remarks.—The pinnules are from 10 to 15 mm. in length leaving the rachis at about 90 degrees. The central vein is strongly marked and the lateral veins bifurcate once or twice.

If the specimens are correctly identified, this is the first record of the species from Britain.

SEMINA INCERTAE SEDIS

SAMAROPSIS Göppert.

1. *Samaropsis* sp. (Pl. XVI, Fig. 4.)

Description.—Seeds oval, 12 mm. long by 8–9 mm. broad; nucule ovate, 5–6 mm. long by 4–5 mm. broad, with a clearly-marked median line, surface longitudinally striated. Wing distinctly emarginate at base and produced above the nucule for about 3 mm. around the micropyle.

Remarks.—These seeds, which were collected at Newbury Pit, differ from *S. fluitans* Dawson (11, p. 165, pl. xii, fig. 74) in size, in the surface of the nucule being striate instead of pitted, and in the wing being broad at the base. From S. *bisectum* Dawson (11, pl. xii, fig. 73), in which the nucule is also striate, they differ in that the wing is neither " widely notched at the apex " nor " more narrowly notched below ". In *S. gutbieri* Geinitz (Kidston, 26, p. 1059, pl. v, fig. 6) the surface is smooth and the seed is broader in proportion to its length. Compared with *S. emarginata* Göpp. and Berger (Kidston, 26, p. 1,058, pl. v, fig. 7) our specimens are more acute as regards the apex of the wing and of the nucule.

2. *Samaropsis* sp.

Description.—Seed broadly cordate, 15 mm. long by 18 mm. broad, base emarginate, apex bluntly rounded. Nucule cordate central; wing 1 mm. broad laterally, 3 mm. broad at base.

Remarks.—This seed was collected at Deep Pit. It differs from any known species of *Samaropsis*, but the specimen is incomplete.

CARPOLITHUS Sternberg.

Carpolithus sp.

Remarks.—Two seeds from Deep Pit, though in size and form resembling *Carpolithus ovoideus* Göpp and Berger sp. (Kidston, 16, p. 404, pl. xxiii, figs. 7, 8) cannot be referred to that species as the testa bears distinct striations, oblique in one case and longitudinal in the other.

HOLCOSPERMUM Nathorst.

Holcospermum sp.

Description.—Seed elongately elliptical, 3·3 cm. long, 1·8 cm. broad in middle. Broadest part occurs about one-third along the seed, where it measures 2 cm. across. Base and apex rounded. Seed bears 4 prominent longitudinal ribs which gradually approach each other at base and apex. Between the ridges are several fine grooves, some traversing the whole length of the seed, others discontinuous. Testa also bears fine oblique striae.

Remarks.—This seed bears some slight similarity to *Radiospermum elongatum* Arber (4, p. 101, pl. vii, figs. 42, 43), but is broader towards the base and narrower towards the apex. The ribs are more strongly marked than in Arber's species, while the testa is not smooth.

LYCOPODIALES.

LEPIDODENDRON Sternberg.

1. *Lepidodendron simile* Kidst., MS. Fide Dr. Kidston. (Pl. XVI, Fig. 2.)

Kidston, 24, p. 137; 25, p. 134; 26, pp. 1038, 1079.—Vernon, 35, pl. lvii, fig. 7.

Remarks.—Several fossils, from Speedwell, Deep and Mells Pits, which I had identified as *L. ophiurus* Brongt., were referred by the late Dr. Kidston to his species, the description of which has not been published. Arber (2, p. 151; 8, p. 200) rejected *L. simile*, but the specimens are retained provisionally under that name.

2. *Lepidodendron* sp.

Description.—Leaf-cushions elongate-rhomboidal, 7 mm. long by 3 mm. broad, apex bluntly pointed, lower angle inflected. Leaf-scar 2 mm. broad by 1 mm. high, situated 1½ mm. down the leaf-cushion, rhomboidal, upper and lower margins rounded, lateral angles prominent and sharp. The three cicatricules are placed half-way down the scar, all punctiform. Ligular cicatricule visible. Field beneath scar ornamented by a vertical series of broad, transverse lines which open out as the cushion is descended, forming rhomboidal markings which, in some cases, are almost as large as the leaf-scar itself. In addition, the field bears numerous fine transverse lines, visible only under the lens.

Remarks.—The specimens, which were collected at Bromley, differ from *L. rimosum* Sternb. (Zeiller, 38, p. 449, pl. lxvii, figs. 4, 5) in the less elongated and less sharply pointed apex of the leaf-cushion, and in the absence of lines leaving the lateral angles of the scar, while the ornamentation of the field appears to be peculiar.

Lepidostrobus Brongniart.

Lepidostrobus radians Schimper.

Schimper, 33, 11, p. 63.—Arber, 8, p. 184, pl. ix, figs. 28–31.

Bark of Unknown Lycopod.

Remarks.—A single specimen of bark was collected which is very similar to the " Bark of an Unknown Plant " as figured by Vernon (35, p. 623, pl. lviii, fig. 4), who remarks that " The specimen appears to be the bark of a Lycopodiaceous plant somewhat similar to, but quite distinct from, *Bothrodendron* ". In the specimen in hand there are numerous strongly marked transverse wrinkles in addition to the longitudinal striations on Vernon's specimen, and the leaf-scars are not so distant. The leaf-scars are 2 mm. wide by 1 mm. high, and the three cicatricules are situated halfway down the scar.

EQUISETALES.

Asterophyllites Brongniart.

1. *Asterophyllites longifolius* Sternb. sp.

L. & H., 30, pl. xviii.—Zeiller, 38, p. 374, pl. lix, fig. 3.—White, 37, p. 153, pl. xlix, figs. 2–4.—Renier, 32, pl. xlix.

2. *Asterophyllites charaeformis* Sternb. sp.

Kidston, 24, p. 119, pl. xi, figs. 2–5.—Kidston, 25, p. 121.

Palaeostachya Weiss.

Palaeostachya pedunculata Williamson.

Zeiller, 38, p. 382, pl. lx, figs. 1, 2.—Kidston, 24, p. 126, —Kidston, 21, pl. xxxiv, fig. 5.

Annularia Sternberg.

Annularia (?) *microphylla* Sauveur.

Kidston, 25, p. 172, pl. x, figs. 1–3.

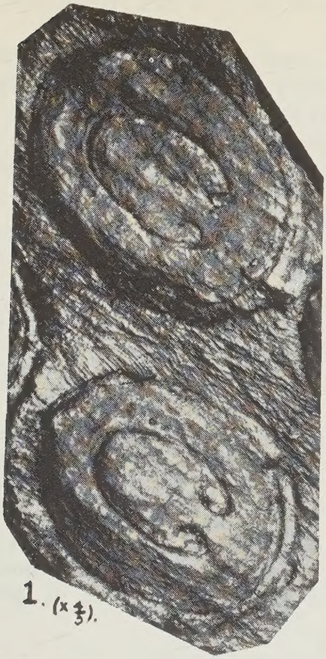
SPHENOPHYLLALES.

Sphenophyllum Brongniart.

1. *Sphenophyllum* (? *Asterophyllites*) *fasciculatum* (Lesqx.).

White, 37, p. 183, pl. l, figs. 1–4.

Description.—Stem up to 1 mm. broad. Whorls of 3–6 leaves at



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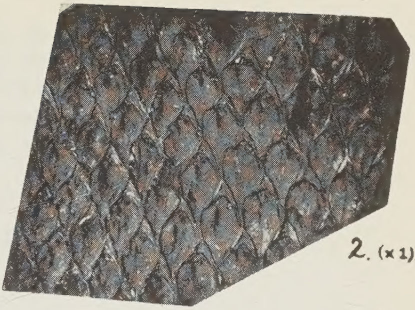

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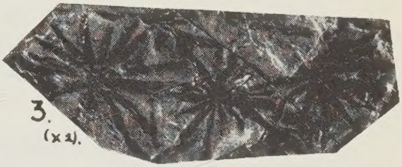

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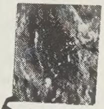

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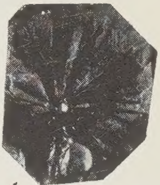

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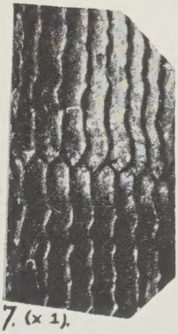

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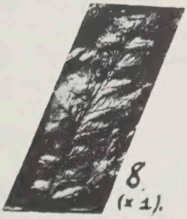

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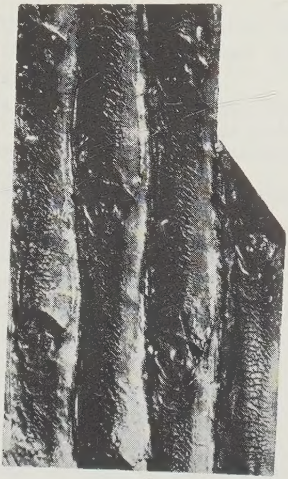

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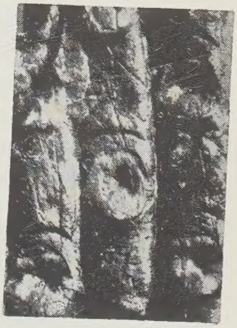

10. (× 1).

R. Crookall, photo.

FOSSIL PLANTS FROM THE BRISTOL AND SOMERSET COALFIELD.

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nodes, bifurcated near base, up to 5 mm. long. Leaves linear, spreading, with sharply pointed apex, single-veined.

Remarks.—This is the first record of *S. fasciculatum* from Britain.

2. *Sphenophyllum* (?) *oblongifolium* Germar and Kaulfuss, sp.

Zeiller, 40, p. 119, pl. xxxv, figs. 1–6.—Potonié, 31, vii, No. 140, figs. 1–4.

CORDAITALES.

Cordaicarpus Geinitz.

Cordaicarpus ovoideus (Berg.)

Arber, 4, p. 100, pl. vii, fig. 30.—*Carpolithes ovoideus* Kidston, 16, p. 404, pl. xxiii, figs. 7, 8.—Kidston, 22, p. 367, pl. lii, fig. 1.

Description.—Seeds oval with a smooth testa, 3–4 mm. long by 2–3 mm. broad.

III. Palaeobotanical Horizons.

Fossil plants were first used in subdividing the Upper Carboniferous Formation of Britain by the late Dr. Kidston (19, p. 183) who, in 1894, proposed the following classification :—

Coal Measures {
Upper Coal Measures.
Transition Series.
Middle Coal Measures.
Lower Coal Measures.
Millstone Grit.

In 1905, Kidston (23, p. 308) pointed out that these terms had often been used in a purely local sense and the following change in nomenclature was proposed :—

Upper Coal Measures = Radstockian Series (including Keele Group).
Transition Series = Staffordian Series.
Middle Coal Measures = Westphalian Series.
Lower Coal Measures, including part of Millstone Grit = Lanarkian Series.

Watts (36, p. 238) has recently suggested that the term " Yorkian " should be substituted for " Westphalian " Series as applied to the Middle Coal Measures of Britain.

The Staffordshire Series of North Staffordshire has been shown by Walcot Gibson (12, p. 378 ; 13, p. 51) to be composed of three groups—

1. Newcastle-under-Lyme Group,
2. Etruria Marl Group,
3. Blackband Group,

and the fossil floras of these divisions were described by Kidston (23, pp. 301–21), while Arber (5, pp. 129–30) recorded 58 species of plants from the Etruria Marl Group of South Staffordshire. The classification of the Upper Carboniferous Rocks of Britain here adopted is as follows :—

RADSTOCKIAN SERIES	Radstock Group. Keele Group.
STAFFORDIAN SERIES	Newcastle-under-Lyme Group. Etruria Marl Group. Blackband Group.
YORKIAN SERIES.	
LANARKIAN SERIES.	

The characteristic floras of these divisions are indicated below :—

	Positive evidence.	Negative evidence.
RADSTOCKIAN SERIES.	Flora rich in number of species, and especially of the *Cyatheites Pecopterids*. In the basal beds (the Keele Group) a few Yorkian plants also occur (very rarely).	The typical Yorkian and Lanarkian assemblages of plants are absent.
STAFFORDIAN SERIES.	Newcastle-under-Lyme Group : Yorkian plants few and rare. Radstockian plants preponderate. Etruria Marl Group : Intermediate. Blackband Group :— Radstockian plants few and rare. Yorkian plants preponderate. (The relative abundance of the plants occurring, important in all divisions, is of special importance in the Staffordian Series.)	The typical Yorkian and Lanarkian assemblages of plants are absent.
YORKIAN SERIES.	Many species (especially of *Sigillaria*, *Neuropteris*, and *Sphenopteris*) are confined to this division ; other plants, which are rare elsewhere, are here characteristically common.	The *Cyatheites-Pecopterids* are absent.
LANARKIAN SERIES.	Some species are confined to this division, though most are rare and some are restricted in horizontal distribution.	Ditto. As many Lanarkian plants are found in the Yorkian Series also, the chief criterion is negative, consisting in an admixture of Yorkian and Lanarkian species without a typical Yorkian flora.

It should be pointed out, that owing to the rapid progress in palaeobotany Kidston's [1] original lists of the vertical distribution of Coal Measure plants now need revising, and this is true of most subsequently published lists (which were mainly or entirely based on Kidston's).

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[1] Kidston, R., 1894 (19, pp. 238–57).

1. *The Radstock Series.*

Kidston (16, pp. 405–9) showed that *the Radstock Series belongs to the true Upper Coal Measures of Britain,* which he regarded as "part of the Upper Coal Measures or Stephanian of the Continent"[1] and in 1894 (20, p. 571) observed that, "Although such strata as the Radstock and Farrington Series of the Somerset Coalfield . . . are true members of the Upper Coal Measures as developed in Europe, they belong to the lower part of the series; the upper beds, such as occur in certain parts of France, being entirely absent from Britain."[2] Zeiller also held this view (in Kidston, 16, loc. cit.).

All subsequent work has confirmed the above conclusions.

2. *The Farrington Series.*

With regard to the Farrington Series of the Southern or Radstock Area, Kidston (16, p. 410) remarked that: "Palaeontologically, the Farrington Series cannot be separated from the Radstock Series, of which, in fact, they seem to form a part."

Lillie (29, p. 67) investigated the Farrington Series of the Northern or Gloucestershire area, which he also referred to the Upper Coal Measures.

The writer visited several pits which had not been investigated previously from a palaeobotanical point of view and, on the basis of the fossil floras obtained, regards Bishop Sutton New Pit, Marsh Lane Pit, and Norton Hill Pit, as very probably working certain of the lower Farrington seams.[3]

In view of the present increase in the known flora of the Farrington Series, it is necessary to re-examine the palaeobotanical horizons represented. In Table I are given the floras of the Southern and Northern Areas (columns 1 and 2), and the zone in which a species is most frequent or characteristic (column 3: R = Radstockian Series, Y = Yorkian Series, L = Lanarkian Series). In columns 4 and 5 are shown those plants which are known elsewhere from the Keele Group and from the Newcastle-under-Lyme Group respectively.[4]

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[1] R. Kidston, 25, p. 74.

[2] Arber (6, pp. 8–11, and 1, pp. 37–8) regarded all the recorded British Coal Measure floras as Westphalian in affinity, maintaining that "there is no evidence of any true Stephanian flora from British rocks".

[3] See Arber, 4, p. 101, and Greenwell & M'Murtrie, 1864 (*The Radstock Portion of the Somerset Coalfield,* Newcastle, p. 27).

[4] Arber, E. A. N. (3, pp. 233–81). The whole of the productive Coal Measures of the Forest of Dean Coalfield are referred to the Upper Coal Measures, but, while Kidston (28, p. 54) refers the First Division (= Woorgreens Coals) to the Radstock Group, the Second Division Coals and the Yorkley Seam are referred to the Newcastle-under-Lyme Group. For floras of Keele and Newcastle-under-Lyme Groups see also Kidston, 23, pp. 311–14; 26, pp. 1020–2, 1078–80; 27, pp. 46–9, and Vernon, R. D., 35, p. 587.

TABLE I.—THE FLORA OF THE FARRINGTON SERIES.

	Southern Area.	Northern Area.	Zone.	Keele Group.	Newcastle Group.
Renaultia chaerophylloides Brongt. sp.	—	×	Y	—	×[1]
Sphenopteris neuropteroides Boul. sp.	×	×	R	× ?	×
,, *alata* Brongt.	—	×	R	—	—
,, *pecopteroides* Kidst.	—	×	R	—	—
,, *macilenta* L. & H.	×	—	R	—	×[1]
Radstockia sphenopteroides Kidst sp.	—	×	R	—	—
Neuropteris macrophylla Brongt.	×	×	R	×	×
,, *scheuchzeri* Hoffm	×	×	R	×	×
,, *rarinervis* Bunb.	×	×	R	×	×
,, *flexuosa* Sternb.	×	×	R	×	×
,, *ovata* Hoffm.	×	×	R	×	×
,, *fimbriata* Lesqx.	×	×	R	—	×
Cyclopteris orbicularis Brongt.	—	×	?	—	×
Pecopteris unita Brongt.	×	×	R	×	×
,, *crenulata* Brongt.	×	×	R	—	×[1]
,, *arborescens* Schl. sp.	×	×	R	×	×
,, *pteroides* Brongt.	—	×	R	—	—
,, *cyathea* Schl. sp.	×	—	R	×	×
,, *miltoni* Art. sp.	×	×	Y	×	×
,, *oreopteridia* Schl. sp.	—	×	R	—	×[1]
,, *polymorpha* Brongt.	—	×	R	×	×
,, *bucklandii* Brongt.	×	×	R	—	×[1]
Dactylotheca plumosa Art. sp.	×	×	R	—	×
Dicksoniites pluckenetii Schl. sp.	×	×	R	—	—
Odontopteris lindleyana Sternb. sp.	×	×	R	×	×
Alethopteris lonchitica Schl. sp.	×	×	YL	—	×
,, *grandini* Brongt. sp.	×	×	R	×	×
,, *serlii* Brongt.	×	×	R	×	×
,, *davreuxi* Brongt. sp.	×	×	Y ?	×	×
,, *aquilina* Schl. sp.	×	×	R	×	×
,, *pontica* Zeiller	—	×	—	—	—
Dictyopteris obliqua Bun.	×	—	Y	—	—
Mariopteris muricata Schl. sp.	×	×	YL	—	×
Crossotheca pinnatifida Gut. sp.	—	×	R	—	—
,, *crepini* Zeiller	—	×	Y	—	—
Aphlebia crispa Gut. sp.	×	×	—	—	×[1]
Rhacophyllum spinosum Lesq.	—	×	R	—	—
,, *goldenbergii* Weiss.	—	×	R	—	—
,, *filiciforme* Gut. sp.	—	×	R	—	—
Caulopteris macrodiscus Brongt.	—	×	R	—	—
Schizospermum noeggerathi Stb. sp.	×	×	R	—	×
Radiospermum elongatum Arber	×	—	—	—	—
Rhabdocarpus lillianus Arber	—	×	—	—	—
Cordaicarpus ovoideus Göpp. & Berg.	×	—	—	—	×[1]
Sigillaria elongata Brongt.	—	×	Y	—	×
,, *voltzii* Brongt.	—	×	Y	—	—
,, *reniformis* Brongt.	—	×	Y ?	—	—

	Southern Area.	Northern Area.	Zone.	Keele Group.	Newcastle Group.
Sigillaria rugosa Brongt.	—	×	Y	—	×
,, *major* L. & H.	—	×	YL	—	—
,, *tessellata* Stein sp.	×	×	Y	×	×
,, *mamillaris* Brongt.	—	×	Y	—	—
,, *deutschiana* Brongt.	—	×	Y	—	—
,, *cumulata* Weiss	×	—	R	—	× [1]
,, *m'murtriei* Kidst.	×	—	R	—	—
,, *principis* Weiss	×	—	Y	—	—
,, *nortonensis* n.sp.	×	—	—	—	—
,, *ovata* Sauv.	×	—	Y	—	× [1]
Lepidodendron lanceolatum Lesqx.	×	×	R	—	×
,, *loricatum* Arber (pars)	×	×	—	—	×
,, *aculeatum* Sternb.	×	×	YL	—	×
,, *rimosum* Sternb.	—	×	Y	—	—
,, *wortheni* Lesqx.	×	×	—	—	×
Lepidostrobus triangularis Zeill.	×	—	Y	—	× [1]
,, *majus* Brongt.	—	×	R	—	×
,, *hastatus* Lesqx.	—	×	R	—	—
,, *brevifolius* Lesqx.	—	×	R	—	×
,, *minor* Goode	×	×	Y	—	× [1]
,, *lanceolatus* L. &. H. sp.	×	×	YL	×	×
Asolanus camptotaenia Wood	×	×	—	—	×
Sigillariophyllum bicarinatum L. & H. sp.	×	×	—	×	× [1]
Lepidophloios laricinus Sternb.	×	×	Y	—	× ?
Stigmaria ficoides Sternb. sp.	×	×	—	×	×
Calamites carinatus Sternb.	×	×	YL	—	×
,, *suckowii* Brongt.	×	×	YL	×	×
,, *cistii* Brongt.	—	×	—	× ?	× ?
Annularia stellata Schl. sp.	×	×	R	×	×
,, *sphenophylloides* Zenk. sp.	×	×	R	×	×
,, *radiata* Brongt.	—	×	YL	×	× ?
Asterophyllites equisetiformis Schl. sp.	×	×	—	×	×
,, *longifolius* Sternb. sp.	—	×	Y	—	—
Pinnularia capillacea L. & H. sp.	×	×	—	—	× ?
Macrostachya ? infundibuliformis Bgt. sp.	—	×	R	—	×
Sphenophyllum emarginatum Bgt.	×	×	R	×	×
,, *majus* Bronn.	× ?	×	Y	—	× [1]
,, *cuneifolium* Sternb.	—	×	YL	—	×
Cordaites angulosostriatus Kidst.	×	×	R	×	×

(*a*) The flora of the Farrington Series of the Southern Area consists of 27 Radstockian and 14 Yorkian (and Lanarkian) species in addition to 13 plants which are of doubtful or of no zonal value. All the common and fairly common plants recorded are Radstockian, while the Yorkian species are invariably of rare occurrence. Though the *Cyatheites-Pecopterids* are comparatively well-represented, they are less frequent than in the Radstock Group of the Radstockian Series, and some of the rarer Radstockian plants are unknown from these rocks. The proportion of Yorkian plants present is higher than in the Radstock Group. On this evidence *the Farrington Series of the Southern Area is referred to the lowest group of the Radstockian Series, namely the Keele Group.*

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[1] Recorded from the Newcastle-under-Lyme Group (for the first time) in the present work. (See *Flora of Central Area of Coalfield*, p. 399.)

(*b*) The flora of the Farrington Series of the Northern Area contains 38 Radstockian, 23 Yorkian (and Lanarkian), and 14 doubtful or non-zonal species. Although the Radstockian species again preponderate they are usually rarer than in the Southern Area, while the proportion of Yorkian species is greater. The flora includes several species which are unknown from the Radstock Group or from the Farrington Series of the Southern Area. The rare occurrence of a number of Radstockian plants and the apparent absence of others, combined with the presence of a fairly high proportion of Yorkian species, indicate that these beds belong to the Transition or Staffordian Series, and *the Farrington Series of the Northern Area is referred to the uppermost or Newcastle-under-Lyme Group of the Staffordian Series.* Reference to columns 4 and 5 of Table 1, in which these floras are compared with those of the Keele and Newcastle-under-Lyme Groups as developed elsewhere, lends support to the above determinations.

3. *The Central Area of the Coalfield.*

In Table II, p. 399, are shown the floras of the Broad Oak Colliery, Pensford, and the Bromley Colliery, near Pensford. The fourth and fifth columns show which of the plants have been recorded elsewhere from the Staffordian Series and from the Newcastle-under-Lyme Group of that Series respectively.

The Pensford flora includes 28 Radstockian and 18 Yorkian (and Lanarkian) species, while the Bromley flora contains 20 Radstockian and 15 Yorkian (and Lanarkian) plants. Although, at both pits, all the *common* species present are Radstockian, the characteristic assemblage of that division is, as a whole, absent. (Only 8 species of *Pecopteris* occur at Pensford and 6 at Bromley, and all are infrequent or rare, whereas in the Radstockian Series the genus is richly represented and several species are characteristically common. Many other typical Radstockian plants are absent from the Pensford and Bromley floras.)

Though the Yorkian species present are comparatively few and of rare occurrence, the majority of these plants have never been recorded from the Radstockian Series. Thus, at Pensford and Bromley the floras are predominantly, though not characteristically Radstockian, and these Coal Measures must be classed with the Staffordian Series.

The next consideration is to which Group of the Staffordian Series the beds belong. As the proportion of Yorkian plants is small, while all the common species are Radstockian, the uppermost

TABLE II.—FLORA OF THE CENTRAL AREA.

	Pensford	Bromley	Zone	Staffordian Series	Newcastle Group
Pecopteris oreopteridia Schl. sp.	×	× ?	R	×	× [1]
,, *polymorpha* Brongt.	×	—	R	×	×
,, *miltoni* Art. sp.	×	×	Y	×	×
,, *crenulata* Brongt.	×	×	R	×	× [1]
,, *arborescens* Schl. sp.	×	—	R	×	×
,, *candolliana* Brongt.	×	×	R	—	—
,, *bucklandii* Brongt.	×	—	R	×	× [1]
,, *unita* Brongt.	—	×	R	×	×
Dactylotheca plumosa Art. sp.	×	×	R	×	×
Eupecopteris camertonensis Kidst.	—	×	R	—	—
Corynepteris sternbergii Ett. sp.	×	—	Y	—	—
Sphenopteris neuropteroides Boul. sp.	×	×	R	×	×
,, *macilenta* L. & H.	×	×	R	—	—
,, *laurenti* Andrae	—	×	Y	×	—
Renaultia chaerophylloides Bgt. sp.	×	—	Y	×	× [1]
Mariopteris muricata Schl. sp.	×	×	YL	×	×
Alethopteris serlii Brongt. sp.	×	×	R	×	×
,, *davreuxi* Brongt. sp.	×	—	Y ?	×	×
,, *aquilina* Schl. sp.	×	×	R	×	×
Neuropteris flexuosa Sternb.	×	×	R	×	×
,, *scheuchzeri* Hoffm.	×	×	R	×	×
,, *fimbriata* Lesqx.	×	×	R	×	×
,, *ovata* Hoffm.	×	×	R	×	×
,, *schlehani* Stur.	×	—	Y	—	—
,, *rarinervis* Bunb.	×	×	R	×	×
,, *macrophylla* Brongt.	×	×	R	×	×
,, *heterophylla* Brongt.	—	×	YL	×	—
Aphlebia crispa Gutb.	×	—	—	×	× [1]
Odontopteris lindleyana Sternb.	×	×	R	×	×
,, *alpina* (Stb.) Gein.	×	—	Y	—	—
Cyclopteris orbicularis Brongt.	—	×	?	×	×
Trigonocarpus parkinsoni Bgt.	×	×	YL	×	—
Radiospermum perpusillum Lx. sp.	×	—	YL	—	—
Holcospermum mamillatum Lx. sp.	×	—	—	×	—
Cordaicarpus ovoideus Göpp. & Berg.	×	—	—	—	—
Sigillaria ovata Sauv.	×	—	Y	×	—
,, *tessellata* Stein sp.	×	×	Y	×	×
,, *cumulata* Weiss var. *nodosa* L. & H.	×	—	R	—	—
,, *mauricii* Grand 'Eury.	×	—	—	—	—
,, *transversalis* Bgt. var. *sparsifolia* Boul.	×	—	Y	—	—
,, *kidstoni* n.sp.	×	—	—	—	—
Sigillariophyllum bicarinatum L. & H. sp.	×	×	—	—	× [1]
Lepidodendron aculeatum Sternb.	×	×	YL	×	×
,, *wortheni* Lesqx.	×	×	—	×	×
,, *lanceolatum* Lesqx.	×	×	R	×	×

	Pensford	Bromley	Zone	Staffordian Series	Newcastle Group
Lepidodendron distans, Lesqx.	×	—	L	—	—
,, *obovatum*, Sternb.	—	×	YL	×	—
Lepidostrobus brevifolius Lesqx.	×	—	R	×	×
,, *lanceolatus* L. & H. sp.	×	×	YL	×	×
,, *minor* Goode	×	×	Y	×	× [1]
,, *triangularis* Zeill.	×	—	Y	×	—
,, *majus* Brongt. sp.	×	—	R	×	×
Stigmaria ficoides Sternb. sp.	×	×	—	×	×
Calamites carinatus Sternb.	×	×	YL	×	×
,, *suckowii* Brongt.	—	×	YL	×	×
Asterophyllites equisetiformis Schl. sp.	×	—	—	×	×
Annularia sphenophylloides Zen. sp.	×	×	R	×	×
,, *stellata* Schl. sp.	×	×	R	×	×
,, *radiata* Brongt.	—	×	YL	×	×
Pinnularia capillacea L. & H. sp.	×	×	—	×	× ?
Stachannularia tuberculata Stern.	×	—	R	×	×
Sphenophyllum majus Bronn.	× ?	×	Y	—	× [1]
,, *emarginatum* Brongt.	×	×	R	×	×
,, *cuneifolium* Sternb.	×	×	YL	×	×
,, *fasciculatum* Lesqx.	—	×	—	—	—
Cordaites angulosostriatus Kidst.	×	—	R	×	×
,, *borassifolius* Sternb. sp.	—	×	Y ?	×	—
Poacordaites microstachys Gold. sp.	×	—	R	—	—

Group is indicated, and *the Coal Measures worked in the Central Area of the Coalfield at Pensford and Bromley are referred to the Newcastle-under-Lyme Group of the Staffordian Series.* Reference to columns 4 and 5 of Table II (above) shows that almost the entire flora of the Central Area has been recognized previously from the Staffordian Series, and the bulk of it from the Newcastle-under-Lyme Group, thus justifying our determination.

On the floral evidence it is probable that certain of the lower Farrington seams are worked at Pensford and Bromley.

4. *The New Rock and Vobster Series.*

The New Rock and Vobster Series were referred by Kidston [2] to the Transition (= Staffordian) Series.

Table III below, gives the known flora of these rocks, which has been considerably increased in the present work. In the second and third columns are shown those plants which are also found elsewhere in the Staffordian Series and in the Blackband Group of that Series respectively.[3]

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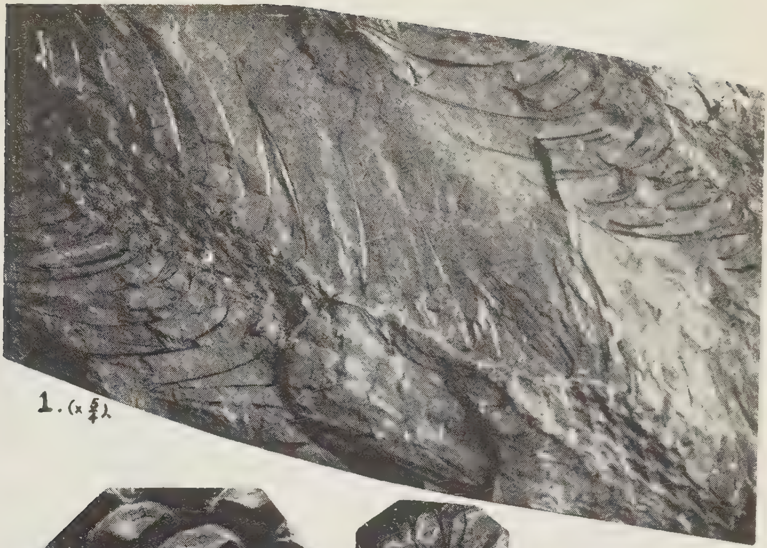
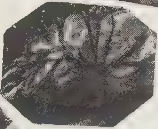
[1] Recorded from the Newcastle-under-Lyme Group (for the first time) in the present work. (See *Flora of Farrington Series of Northern Area*, p. 396.)

[2] R. Kidston, 20, pp. 557–8.

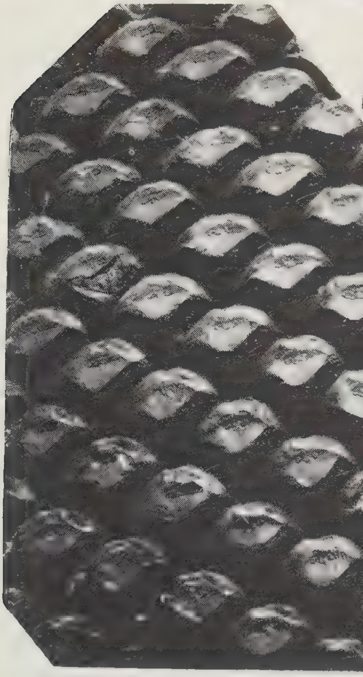
[3] R. Kidston, 23, pp. 311, 321; 27, pp. 46–9; 28, pp. 316, 355.



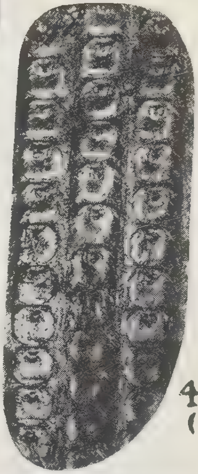
1. ($\times \frac{5}{8}$).



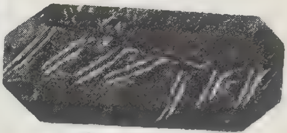
2. ($\times 1$).



3. ($\times \frac{4}{5}$).



4. ($\times \frac{5}{8}$).



5. ($\times 1$).

R. Crookall, photo.

Fossil Plants from the Bristol and Somerset Coalfield.

[*To face p. 400.*

TABLE III.—THE FLORA OF THE NEW ROCK AND VOBSTER SERIES.

	Zone.	Staffordian Series.	Blackband Group.
Pecopteris oreopteridia Schl. sp.	R	×	—
,, *arborescens* Schl. sp.	R	×	—
,, *volkmanni* Sauv.	Y	—	—
,, *miltoni* Art. sp.	Y	×	×
Dactylotheca plumosa Art. sp.	R	×	×
Mariopteris muricata Schl. sp.	YL	×	×
Neuropteris pseudogigantea Pot.	YL	×	×
,, *scheuchzeri* Hoffm.	R	×	×
,, *heterophylla* Brongt.	YL	×	×
,, *macrophylla* Brongt.	R	×	×
,, *obliqua* Brongt.	Y	×	×
,, *rarinervis* Bunb.	R	×	×
Cyclopteris orbicularis Brongt.	?	×	—
Dictyopteris munsteri Eich. sp.	Y	×	×
Sphenopteris tenuissima Presl.	Y	—	—
,, *laurenti* Andrae	Y	×	—
,, *dilatata* L. & H.	Y	×	×
,, *neuropteroides* Boul. sp.	R	×	—
,, *trifoliolata* Art. sp.	Y	—	—
Corynepteris sternbergii Ett. sp.	Y	× [1]	—
,, *coralloides* Gut. sp.	Y	×	—
Diplotmema furcatum Brongt. sp.	Y	×	—
Alethopteris lonchitica Schl. sp.	YL	×	×
,, *decurrens* Art. sp.	YL	×	—
Desmopteris elongata Presl.	R	—	—
Megalospermum inflatum Lesqx. sp.	Y	—	—
Sigillaria elongata Brongt.	Y	×	—
,, *cordigera* Zeill.	Y	—	—
,, *tessellata* Stein. sp.	Y	×	—
,, *major* L. & H.	YL	×	×
,, *cumulata* Weiss.[2]	R	× [1]	—
,, *mamillaris* Brongt.	Y	×	—
,, *scutellata* Brongt.	YL	×	—
,, *rugosa* Brongt.[3]	Y	×	—
,, *tenuis* Achep.[4]	Y	—	—
,, *saulii* Brongt.	Y	—	—
,, *ovata* Sauv.	Y	×	×
Asolanus camptotaenia Wood	—	×	—
Stigmaria ficoides Sternb. sp.	—	×	×
,, *minuta* Göpp.	Y	—	—
Lepidodendron aculeatum Sternb.	YL	×	—
,, *rimosum* Sternb.	Y	×	×
,, *obovatum* Sternb.	YL	×	—
,, *ophiurus* Brongt.	YL	×	—
,, *wortheni* Lesqx.	—	×	×
,, *lanceolatum* Lesqx.	R	×	—
,, *simile* Kidst.	YL	× ?	—

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[1] Recorded from the Staffordian Series (for the first time) in the present work. See Floras of Northern and Central Areas, pp. 396, 399.

[2] Recorded (Kidst., 16, p. 413) as *S. tessellata*, see Kidst., 23, p. 317.

[3] Recorded (Kidst., 16, p. 415) as *S. sillimani*, see Kidst., 20, p. 577.

[4] Recorded (Kidst., 16, p. 415) as *S. schlotheimii*, see Kidst., 20, p. 576.

	Zone.	Staffordian Series.	Blackband Group.
Lepidostrobus minor Goode	Y	×	—
„ *triangularis* Zeill.	Y	×	—
„ *morissianum* Lesqx.	—	—	—
„ *majus* Brongt. sp.	R	×	—
„ *incertus* Lesqx.	—	—	—
„ *radians* Schimp.	Y	—	—
„ *lanceolatus* L. & H. sp.	YL	×	×
Sigillariophyllum bicarinatum L. & H. sp.	—	× [1]	—
Calamites suckowii Brongt.	YL	×	×
„ *carinatus* Sternb.	YL	×	×
„ *undulatus* Sternb.	YL	×	×
Annularia radiata Brongt.	YL	×	×
„ *sphenophylloides* Zenk. sp.	R	×	×
Asterophyllites equisetiformis Schl. sp.	—	×	×
„ *grandis* Sternb. sp.	Y	×	×
„ *charaeformis* Sternb. sp.	Y	×	×
Palaeostachya pedunculata Will.	Y	×	—
Pinnularia capillacea L. & H. sp.	—	×	—
Sphenophyllum cuneifolium Sternb.	YL	×	×
„ *myriophyllum* Crépin	Y	×	—
„ *trichomatosum* Stur.	Y	—	—
„ *emarginatum* Brongt.	R	×	×
Dorycordaites palmaeformis Gut.	Y	×	—
Cordaites principalis Germ. sp.	Y	×	—
„ *borassifolius* Sternb. sp.	Y ?	×	×
„ *angulosostriatus* Kidst.	R	×	—
Artisia approximata Brongt. sp.	—	×	—
„ *transversa* Art. sp.	—	×	×
Cordaicarpus cordai Gein. sp.	Y	×	—
„ *areolatus* Boul. sp.	Y	—	—
„ *ovoideus* Göpp. & Berg.	—	× [1]	—

The flora of the New Rock and Vobster Series is seen to contain 14 Radstockian in association with 51 Yorkian (and Lanarkian) species.

The Radstockian species present are not only comparatively few, but are invariably of rare occurrence, many of the records being represented by a single specimen only.

Of the 51 Yorkian species recorded, most are unknown from the Radstockian Series, the remainder being extremely rare in those rocks.

In spite, however, of the preponderance of Yorkian plants in the New Rock and Vobster Series, the typical Yorkian assemblage cannot be recognized in the flora. Thus—

(*a*) At least 37 species of *Sigillaria* are known which occur only in and below the Yorkian Series, and none of which are found in the New Rock and Vobster Series.

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[1] Recorded from the Staffordian Series (for the first time) in the present work. See Floras of Northern and Central Areas, pp. 396, 399.

Further, the 11 Yorkian *Sigillarias* recorded above from the New Rock and Vobster Series are all rare or fairly rare in these rocks, whereas several are characteristically common in the Yorkian Series.

(*b*) With regard to the *Sphenopterideae*, constituting one of the main features of the Yorkian flora, and of which over 100 species are known only from or below that Series, 8 species only have been found in the New Rock and Vobster Series, and 6 of these are represented by a single specimen in our collection.

(*c*) The Yorkian *Neuropterids* here recorded are also rare (whereas they are mostly common in that Series), and many other species of *Neuropteris* characteristic of the Yorkian Series are absent.

It will be seen that these rocks contain a transition flora in which, though the proportion of Yorkian plants is large, a typical assemblage of that division cannot be recognized, and it is evident that *the New Rock and Vobster Series must be referred to the lowest group of the Staffordian Series, namely the Blackband Group.*

This determination receives support by a comparison of the flora of the New Rock and Vobster Series with that of the Blackband Group of the Staffordian Series of other British coalfields (columns 2 and 3 of Table III above).

5. *The Pennant Rock.*

With regard to the horizon of these beds, Kidston (20, p. 578) remarked that, " The few fossils I have been able to identify from the Pennant Rocks represent so few species that there is no palaeontological evidence available for deciding this point. If, however, we examine the fossil plants of the Upper Coal Measures which overlie the Pennant, and compare them with those of the New Rock Series on which the Pennant rests, and which is clearly transitionary between the Upper and Middle Coal Measures, the Pennant Rock of Somerset must obviously be either the basement beds of the Upper Coal Measures or the upper portion of the Transition Series."[1]

We have few additions to make to the flora of the Pennant Rock, but, as the Farrington Series (in the Northern Area) has been referred (above) to the Staffordian Series, it is evident that *the Pennant Rock of the Northern Area belongs to the Staffordian Series.*

6. *The Upper Beds of the " Millstone Grit ".*

Although comparatively few species of plants were collected from the upper beds of the " Millstone Grit ", some are of very frequent occurrence.

Sphenophyllum trichomatosum Stur. is extremely common, and hitherto has not been found outside the Yorkian Series.

Odontopteris conwayi L. & H. sp., which is equally abundant, is known from the Yorkian Series only.

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[1] Stamp (34, p. 158) observes : " . . . in the Bristol and Somerset Coalfield the Pennant Grit occurs high up in the Staffordian " ; but cites no authority.

Lepidodendron distans Lesqx. is a characteristic Yorkian and Lanarkian plant, and has not hitherto been found above the Yorkian Series.

Lepidophloios laricinus Sternb. occurs chiefly in the Yorkian Series, though it is found, very rarely, in the higher divisions.

Calamites undulatus Sterb. is much more common in the Yorkian and Lanarkian Series than elsewhere.

Lepidostrobus lanceolatus L. & H. sp. is frequent both in the Yorkian and the Lanarkian Series and becomes rarer in the Staffordian Series.

Stigmaria ficoides Sternb. sp. and *Sigillariophyllum bicarinatum* L. & H. sp. are of no zonal value, as they occur more or less abundantly throughout the Coal Measures.

Observing the entire absence of Radstockian species in the above flora, together with the very common occurrence of certain typical Yorkian plants, although a rich variety of Yorkian species has not been found, *the upper beds of the "Millstone Grit" of this district is provisionally referred to the Yorkian Series.*

Thus, although lithologically the upper beds of the "Millstone Grit" of the Bristol and Somerset Coalfield resembles that of the North Midlands Coalfields, it appears to be palaeontologically referable to the Yorkian Series, as was shown by Goode (14, p. 275) to be true of the "Millstone Grit" of Pembrokeshire.[1]

IV. General Remarks on Distribution of Flora.

Pteridospermae and Filicales.

1. *Pecopterideae.*—The Radstock Series is chiefly characterised by the presence of 16 species of *Pecopteris*, the most frequent of which are *P. miltoni*, *P. arborescens*, *P. oreopteridia*, and *P. unita*. Many of the Radstockian *Pecopterids* are found in the Farrington Series of the Southern Area, where, however, they are generally less frequent. In the Central Area and in the Farrington Series of the Northern Area they are still less frequent. From the New Rock and Vobster Series only two Radstockian species of *Pecopteris* have been recorded, both being extremely rare, while the Yorkian plant, *P. volkmanni*, is found here.

Dactylotheca plumosa occurs throughout the coalfield, though it is more abundant in the Radstock Series than elsewhere.

Dicksoniites pluckenetii is nowhere common, and is confined to the Radstock and Farrington Series.

Mariopteris muricata, widely distributed throughout the coalfield, is rare in the Radstock Series and becomes more frequent in the lower rocks.

---

[1] Kidston (28, p. 10) has remarked that "The term 'Millstone Grit', as frequently used in geological writings, has been applied very loosely to coarse sandstone beds belonging to the Lower Carboniferous as well as to the Upper Carboniferous, and their true geological position can only be determined by their fossil contents, frequently difficult to obtain". See also Arber (3, p. 269) and Kidston (26, p. 1065).

2. *Alethopterideae.*—Of the six species of *Alethopteris* known from the Radstock Series, only one, *A. serlii*, is common, and this is extremely abundant. It is less frequent in the Farrington Series, and especially in the Northern Area. In the New Rock and Vobster Series this typical Radstockian species is unknown, and the Yorkian plants *A. lonchitica* and *A. decurrens* are found. *Desmopteris elongata* is extremely rare.

3. *Odontopterideae.*—*Odontopteris lindleyana*, found in the Radstock and Farrington Series at several localities, is rare, while *O. alpina* is known from one locality only. *O. conwayi* is very abundant in the upper beds of the " Millstone Grit ", but has not been found elsewhere in the coalfield.

4. *Sphenopterideae.*—While several species of *Sphenopteris* have been recorded from the Radstock and Farrington Series, nearly all are rare, the most frequent being *S. neuropteroides.*

In the New Rock and Vobster Series the Radstockian *Sphenopterids* are absent and are replaced by seven rare or fairly rare species which are unknown from the Radstock Series.

The genera *Radstockia*, *Renaultia*, *Crossotheca*, and *Unatheca* are rare.

5. *Neuropterideae.*—In the Radstock and Farrington Series the genus *Neuropteris* is represented by six species, the most common forms being *N. macrophylla*, *N. scheuchzeri*, *N. ovata*, and *N. flexuosa.* These plants are absent from or very rare in the new Rock and Vobster Series, where *N. pseudogigantea* and *N. heterophylla* appear.

None of the species of *Dictyopteris* or *Rhacophyllum* is common or widely distributed.

6. *Fern Stems.*—The genera *Megaphyton* and *Caulopteris* are restricted to the Radstock and Farrington Series, where they are of rare occurrence.

Semina Incertae Sedis.

Schizospermum noeggerathi is confined to the Radstock and Farrington Series, *Holcospermum mamillatum* to the Central Area, *Radiospermum elongatum* and *Rhabdocarpus lillianus* to the Farrington Series, and *Megalospermum inflatum* to the New Rock Series. All the species of seeds found in the coalfield are more or less rare, and are restricted in horizontal distribution.

Lycopodiales.

(1) With regard to the *Lepidodendrae*, *L. wortheni*, known from the Middle to the Upper Coal Measures, is the most common species throughout the coalfield. *L. aculeatum* and *L. lanceolatum* are also frequent in the Radstock and Farrington Series. *L. loricatum*, a typical plant of the Transition Coal Measures, appears in the Farrington Series.

L. simile, *L. ophiurus*, and *L. obovatum* are found in the New Rock and Vobster Series, where they are rare.

(2) The genus *Lepidophloios* is extremely rare, and is recorded from two or three localities only.

(3) The commonest *Sigillaria* of the Radstock and Farrington Series is *S. cumulata*. Several species of *Sigillaria* are confined to the New Rock and Vobster Series, but none is frequent.

(4) *Asolanus* occurs at several localities, but is very rare.

(5) While *Sigillariostrobus* has been found in the Radstock Series only, certain species of Lepidostrobus (*L. minor* and *L. lanceolatus*) occur throughout the coalfield, while others (*L. morissianum* and *L. incertus*) are restricted to the lower rocks, where they are rare.

Equisetales.

The genus *Calamites* is fairly rare, though certain species (*C. suckowii* and *C. carinatus*) are found in each Series. *C. undulatus*, extremely rare in the Radstock Series, is more frequent in the New Rock Series.

Asterophyllites equisetiformis occurs, though rarely, throughout the coalfield, while *A. grandis* and *A. charaeformis* are restricted to the New Rock Series.

Annularia stellata and *A. sphenophylloides*, common and characteristic plants of the Radstock Series, are less frequent in the Farrington Series, and the former is unknown while the latter is extremely rare in the New Rock and Vobster Series. *A. radiata* appears in the Farrington Series of the Northern Area and becomes more frequent in the New Rock Series. The fructifications of *Calamites* are rarely found.

Sphenophyllales.

The genus *Sphenophyllum* is represented in the Radstock Series by *S. emarginatum*, a common and characteristic plant. This species is rarer in the Farrington Series, extremely rare in the New Rock Series and absent from the Vobster Series. *S. majus* and *S. cuneifolium* appear in the Farrington Series, and the latter becomes much more frequent in the New Rock and Vobster Series, where it is joined by *S. myriophyllum* and *S. trichomatosum*. The last, which is rare in the New Rock Series, is found, in great abundance, in the upper beds of the " Millstone Grit ".

Cordaitales.

Cordaites angulosostriatus, a common and characteristic plant of the Radstock Series, is rarer in the lower rocks, where *C. borassifolius* and *C. principalis* occur.

Poacordaites microstachys is confined to the Radstock and Farrington Series.

Cordaicarpus areolatus and *C. cordia* are known only from the New Rock Series, where they are rare.

It will be seen that each Series in the Bristol and Somerset Coalfield contains a distinctive flora by which it can be readily identified.

V. SUMMARY AND CONCLUSIONS.

1. With the additional species recorded in Part II of this work, the known flora of the Bristol and Somerset Coalfield has been increased as follows:—

New records from various localities .	444
New records from the Coalfield . .	79
New records from Great Britain .	8
New species (described and figured) .	2

In addition, many species which are already known from particular localities in the Coalfield are recorded for the first time from definite horizons.

2. The known vertical distribution of 45 species has been extended to the Staffordian Series.

3. Palaeobotanical horizons have been determined as follows :—

		Previous determination.	Present determination.
RADSTOCK SERIES.		Upper Coal Measures (= Radstockian Series). (Kidston, 1887.)	Radstock Group of the Radstockian Series.
FARRINGTON SERIES.	Southern Area.	Ditto.	Keele Group of the Radstockian Series.
	? Central Area.	Unknown.	Newcastle-under-Lyme Group of the Staffordian Series.
	Northern Area.	Upper Coal Measures. (Lillie, 1910.)	Newcastle-under-Lyme Group of the Staffordian Series.
PENNANT ROCK.		Either basement beds of Upper Coal Measures, or upper portion of Transition (= Staffordian) Series. (Kidston, 1894.)	(In Northern Area) Staffordian Series.
NEW ROCK AND VOBSTER SERIES.		Transition (= Staffordian) Series. (Kidston, 1894.)	Blackband Group of Staffordian Series.
UPPER BEDS OF "MILLSTONE GRIT".		Unknown.	(Probably) Yorkian Series.

The late Dr. Kidston expressed entire agreement with the above results, and I gladly record my indebtedness to Dr. Kidston for his assistance and encouragement in the work.

My thanks are also due to Miss E. M. Lee for continued help, and to Professor Darbishire for his interest and advice.

I have again to thank the Bristol University Colston Research

Society for defraying the cost of travelling when collecting specimens, and the cost of the plates.

During the course of this investigation I have been in receipt of a maintenance grant from the Department of Scientific and Industrial Research.

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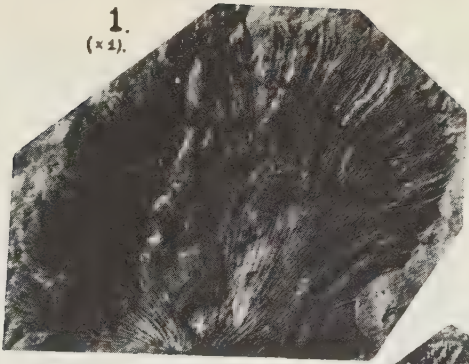

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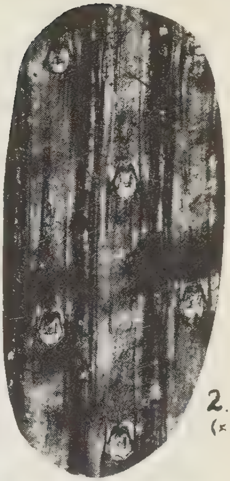

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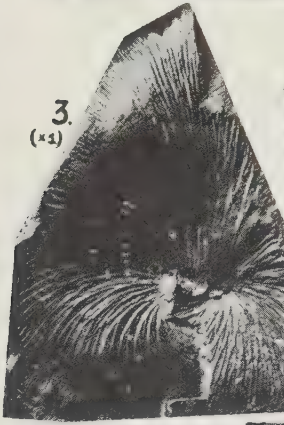

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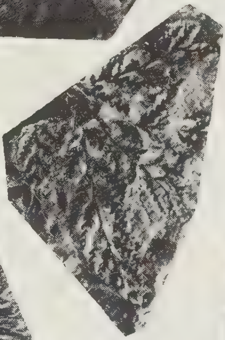

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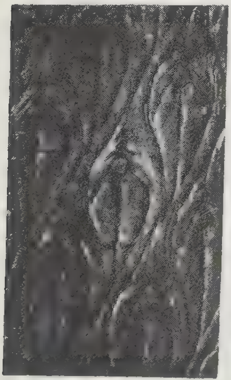

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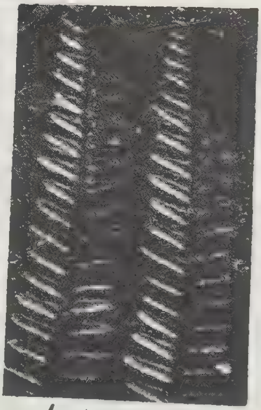

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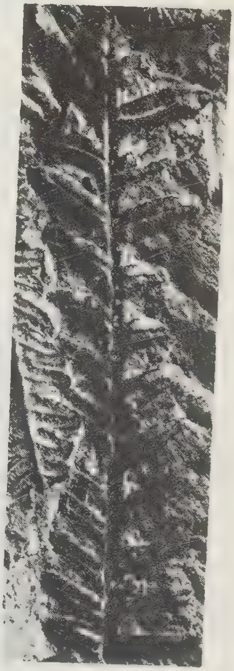

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R. Crookall, photo.

FOSSIL PLANTS FROM THE BRISTOL AND SOMERSET COALFIELD.

[*To face p. 408.*

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EXPLANATION OF PLATES XVI–XVIII.

Plate XVI.

FIG.

1.—*Caulopteris anglica* Kidst., from Radstock. × ⅘
2.—*Lepidodendron simile* Kidst. MS., from Deep Pit, Kingswood, Bristol. × 1.
3.—*Annularia radiata* Brongt., from Deep Pit, Kingswood, Bristol. × 1.
4.—*Samaropsis* sp., from Newbury Pit. × 1.
5.—*Cordaicarpus areolatus* Boulay sp., from Deep Pit, Kingswood, Bristol. × 1.
6.—*Sphenophyllum ? myriophyllum* Crépin, from Deep Pit, Kingswood, Bristol. × 1.
7.—*Calamites undulatus* Sternb., from Deep Pit, Kingswood, Bristol. × 1.
8.—? *Oligocarpia brongniarti* Stur, from Parkfield Pit, near Pucklechurch. × 1.

9.—*Sigillaria mamillaris* Brongt., from Parkfield Pit, near Pucklechurch. × 1.
10.—*Sigillaria saulii* Brongt., from Newbury Pit. × 1.

PLATE XVII.

1.—*Lepidodendron ophiurus* Brongt., from Deep Pit, Kingswood, Bristol. × $\frac{5}{4}$.
2.—*Sphenophyllum trichomatosum* Stur, from Deep Pit, Kingswood, Bristol. × 1.
3.—*Sigillaria m'murtriei* Kidst., from Radstock. × $\frac{4}{5}$.
4.—*Sigillaria tessellata* Stein sp., from Bishop Sutton New Pit. × $\frac{5}{6}$.
5.—*Alethopteris decurrens* Art. sp., from Hanham Pit. × 1.

PLATE XVIII.

1.—*Neuropteris fimbriata* Lesqx., from Broad Oak Colliery, Pensford. × 1.
2.—*Sigillaria rugosa* Brongt., from Parkfield Colliery, near Pucklechurch. × 1.
3.—*Cyclopteris orbicularis* Brongt., from Bromley Colliery, near Pensford. × 1.
4.—*Sphenopteris* sp., from Bishop Sutton, New Pit. × 1.
5.—*Lepidodrendron aculeatum* Sternb., from No. 4 Seam, Bromley Colliery, near Pensford. × $\frac{3}{5}$.
6.—*Eupecopteris* sp., from Parkfield Colliery, near Pucklechurch. × 1.
7.—*Alethopteris aquilina* Schl. sp., from Bishop Sutton New Pit. × 1.

The Tectonics of the Southern Midlands: A Criticism and a Contribution.

By BEEBY THOMPSON, F.G.S., F.C.S.

IN the GEOLOGICAL MAGAZINE for May appeared an article by Dr. R. H. Rastall entitled "On the Tectonics of the Southern Midlands", which I feel it absolutely necessary to criticize and correct in so far as it deals with evidence derived from Northamptonshire and quotations from my own papers, the latter in parts verbally accurate and yet altogether misleading as used; and I trust Dr. Rastall will accept the following corrections and additions rather as a contribution than an adverse criticism merely to his theory of "the recurrence of activity along old-established fold-lines of an early date", in the particular case here to be dealt with the Charnwood Forest anticlinal extension into Northamptonshire. The matters to which particular attention will be drawn are mainly contained in pages 204–5, and will be separately referred to.

I. THICKNESS OF THE UPPER LIAS (pars. 3, 4, p. 204).

The Upper Lias of Northamptonshire does not vary in thickness in the erratic manner indicated by these figures; moreover, if it did, and anticlines were called in to account for it, then such anticlines would have to be all over the county and in all manner of directions, and such a structure could have no bearing on the particular problem discussed in Dr. Rastall's paper. Curiously, all the other misconceptions to be dealt with are dependent upon or mixed up with a belief in a considerable fluctuating thickness of the Upper Lias due to denudation at the close of the Liassic period, which belief I thought I had killed thirty years ago.

It is not reasonable to expect that a hill-side section, even though showing a junction of Northampton Sand with Upper Lias clay, can give the true original thickness of either formation, owing to slipping during the formation of the present valleys either of the clay itself in mass (low-level slipping), or of the Northampton Sand over the clay (high-level slipping), or probably both actions. Indeed, cases have been given where the Northampton Sand with a true maximum thickness of 30 feet covers a hill like a saddle through a vertical range of more than 100 feet. Only where slipping could not have been effective, as on the top of a hill, and less frequently from the bottom of a valley, can we expect to get the true original thickness of the Upper Lias. For this reason Finedon (on a slope) and Burton Latimer (p. 204) cannot be compared for true thickness.

Below is a table of Upper Lias thicknesses, derived from the best information available and arranged as far as possible in order from south-west to north-east so as to show the general gradual *increase in thickness* towards the supposed Charnwood Forest anticlinal extension into Northamptonshire, which it will be perceived is entirely inconsistent with a supposed increased denudation in that direction, due to an uplift at the close of the Upper Lias period.

	ft.		ft.
Steeple Aston	35	Northampton	185 (or more ?)
North Oxfordshire	70 (maximum)	Kingsthorpe	183 (or more ?)
Brackley	109	Finedon	185
Towcester	140 (or more)	Burton Latimer	182
Long Buckby	184	Kettering	184 (probably more)
Brington	180	Desborough	212 (?)
Upton (Berry Wood)	183	Stamford	193 (?)

The reasons for the four corrections made to Dr. Rastall's list are :—(1) TOWCESTER : certainly 119 feet is too little, as the Upper Lias was incomplete at the place from which this figure was derived. (2) NORTHAMPTON : There is only one section, out of a number, at all likely to give the correct original thickness of the Upper Lias, that of the Tower Boring, on the highest ground by the side of the old service reservoir. This well and boring was made in 1877–8, and a diagram of it by the late Mr. Samuel Sharp gave this as :—Well, 62 feet ; boring, 195 feet ; total, 257 feet. Now since 62 feet is the correct thickness of beds to the base of the Northampton Sand here, as may still be verified, and the boring was made to the Marlstone (and somewhat below ?), doubtless the Upper Lias here is 185 feet or more thick. In my notes I long ago corrected the information given by Mr. Frank Tomlinson in 1909, and quoted in *The Water Supply of Beds. and Northants.* (3) FINEDON WELL is on a slope with not even any Northampton Sand on top, hence the correction is made from the nearest known Upper Lias top where slipping had not taken place. (4) KETTERING : Further notes presently. HARTWELL is omitted as the description is too vague to be worth a place in any discussion of thicknesses.

II. GAPS (par. 4, p. 204).

The remarkably regular and concordant thicknesses of the Upper Lias over a large area, as shown in the Table, do not lend aid to a supposition of " considerable gaps in the succession ". The only local gaps that I know of are at the bottom of the Upper Lias (and will be referred to later) and at the junction of the old *communis*-zone—the *braunianus*-zone—with my *jurensis*-zone (in part). There is no such local gap at the top of the Upper Lias that Dr Rastall's theory requires, for wherever a true or normal junction of Northampton Sand and Upper Lias has been observed, and it has also been possible to examine the Upper Lias beds below it, they have been found to contain fossils distinctive of the *jurensis*-zone (part) and to show an entire absence of the distinctive fossils of the *braunianus*-zone. No ammonite zone that was ever present in Northamptonshire is missing through post-Liassic and pre-Inferior Oolite denudation This dogmatic statement, however, does not carry with it as corollaries the implications that every known zone is present or that the Upper Lias and Northampton Sand form an unbroken sequence.

III. PEBBLE BEDS (par. 4, p. 204).

There is no pebble-bed at the junction of the Upper Lias and Inferior Oolite in Northamptonshire in the sense that is implied in this paragraph and that the theory it is requisitioned for requires. I feel now, as I never did before, that I have made a mistake in perpetuating the name " pebble-bed ", for it is only an impressionist name ; the round, smooth-surfaced, black, pebble-like bodies which suggest the name are not pebbles but phosphatic concretions, and they have no connexion whatever with the Upper Lias, but are rather forerunners of the Northampton Sand ; petrologically in being phosphatic like the lower beds of the Northampton Sand commonly are and in which lower beds similar but smaller so-called pebbles occur ; palaeontologically in being associated with brachiopods never found in the Upper Lias, such as *Rhynchonella cynocephala* and some at present unnamed species (see Northamptonshire in *Geology in the Field*). These phosphatic concretions could not have withstood the friction involved in ordinary pebble-making, and moreover are often covered with delicate pittings and other markings which would be easily obliterated by friction. Even the residual Upper Lias nodules, sometimes phosphatized, are not pebbles, they remain flattish as they occurred in the bed from which derived. (See No. IV.)

IV. UPPER LIAS FOSSILS (par. 4, p. 204).

The so-called pebble-bed certainly does not contain " abundant Upper Lias fossils ", far from it : the number of species of Upper Lias fossils is extraordinarily small (see *Geology in the Field*), so small, indeed, that it would be very near to absolute truth to say that only one Upper Lias fossil is ever found in this junction-bed, viz. *Ammonites bifrons*, and this, singularly, is rarely absent, thus giving rise to an interesting speculation as developed below, not because it has any direct bearing on the anticlinal theory, but as a partial reply to the statement made in par. 2, p. 205, that "it is believed that the whole *jurensis* zone is absent, the ironstone series of the Northampton Sands resting directly on clays of the *bifrons-communis* zone".

Firstly, and incidentally, the Northampton Sand does not rest on beds in any way associated with the *communis*-zone. I claim to know the upper beds of the Upper Lias of Northamptonshire better than anyone else, and I say that I have never yet found the least trace of a *communis* type of ammonite in the junction-bed, or a specimen of *A. communis* (or its last representative, *A. braunianus*) in the upper beds of the Upper Lias referred to below.

The beds which I have classified as *jurensis*-zone (in part), and claimed to represent the *variabilis*-beds have yielded 107 species of fossils, of which 73 are new to the Upper Lias of our district, yet towards the top of the zone fossils of any kind get rarer until the bed might be described as unfossiliferous, excepting for the occasional occurrence of *Ammonites bifrons*; at the same time commonly (but not everywhere) flat, argillo-calcareous nodules increase. The difficulty of conceiving how a single thin layer of sometimes sparsely scattered nodules, even if derived from a few feet of denuded clay matrix, could possibly yield so many specimens of a particular ammonite is very great; hence I have been constrained to think that *Ammonites bifrons* is indigenous to the junction-bed and that it lived on in this district through the interregnum represented by the period of deficient sedimentation perhaps corresponding in time to the *striatulus*-beds of other districts.

I know how dreadful this idea will appear to some palaeontologists, so I may as well ease my mind of a further suspicion, viz. that the bottom beds of the Northampton Sand also contain *Ammonites bifrons*, as hinted at by Sharp (cf. Sharp's *Oolites of Northamptonshire*, Pt. I, 1870, p. 366). At various times I have seen specimens of *A. bifrons* very red, as though derived from the ironstone, but always, till recently, relegated them to the nodule-bed as residuals. Recently, however, I obtained from the bottom of the ironstone horizon an unworn specimen of *Ammonites bifrons* containing and enclosed in a white and blue calcareous matrix which if one could be ignorant of the nature of the fossil would certainly be classed as Northampton Sand, judged by the general character of the latter rock at the same place. Here there was no definite black-nodule bed, yet the largest black nodule I have ever obtained was found in near association with the ammonite.

V. FOLDING (par. 4, p. 204).

It is true I have given evidence of foldings, one of the Upper

Lias itself before completion, and others of later date, and could give many others, but the direction of these do not in any way support the contention of an uplift along the supposed Charnwood axis in Northamptonshire. The particular Upper Lias one referred to above is indeed approximately at right angles to the supposed Charnian axis.

VI. THICKNESS OF THE MIDDLE LIAS (par. 1, p. 204).

It will suffice to say in reference to this paragraph that I increased the estimated thickness to 100 feet in 1896 and gave the added portion the name "*nitescens*-zone"; but 100 feet is not an "average thickness", it is an extreme one, for Northamptonshire, and in the direction of the presumed Charnian axis it is getting thinner, and that fact constitutes my contribution to Dr. Rastall's theory.

VII. CONTRIBUTION TO THE THEORY.

Direct evidence of the existence of a continuation of the Charnwood Forest anticline into Northamptonshire is very slender, being confined to the results of a single trial boring for coal in Harrington Dale, near to Orton, in 1883–4; yet a good deal of speculation has been indulged in with respect to such a tectonic feature, which indeed I am going to add to. In the absence of anything better as a substitute, it will be assumed that the axis takes a straight line from Leicester to south of Biggleswade, according to Dr. Rastall's contention, and such a straight line will run very near to Orton and Kettering and Desborough, about which something pertinent may be said.

It is probable that in very early times this Charnian axis separated south-westerly and north-easterly coalfields, either during deposition or after deposition, by an uplift.

It may have been observed, or at least can be observed, that from the south-westerly parts of Northamptonshire to the north-easterly, the tendency is for the Liassic and Lower Oolitic formations to thicken, which, whatever other reasons may be superposed on it, such as supply of sediment and areas of maximum sedimentation, must, considering the great thicknesses involved, mean a regional depression in a north-easterly direction, perhaps spasmodic with long intervals of quiescence. For instance, the greatest combined thickness of Lower and Middle Lias known in Northamptonshire is at the Orton boring (618 feet); the greatest recorded thickness of Upper Lias is at Desborough (212 feet ?); but more important than these for the present contention is the great north-easterly depression which permitted of the formation of the Lincolnshire Oolite. This special depression practically starts from the line of our supposed Charnian axis as though this axis were a feature that could not be coerced into a local subsidence, and acted as a buttress to south-westerly lands.

Yet, with all those features before us of a general sinking and general thickening of deposits to the north-east and of the thickening of the Lias as a whole towards and over the supposed axis, the thickness of the Middle Lias is here less than anywhere else where the thickness is known and the top beds are absent as well as the bottom beds of the Upper Lias. This does look exceedingly like a special uplift along the supposed line of the Charnian axis in the latter part of the Middle Lias period, which may have been essentially local, that is to say, not have extended for long distances along the axis either way. Below is the evidence.

KETTERING.—The thickness of the Middle Lias in all deep borings as recorded has been rather conjectural in the sense that the lower limit was badly defined. A core boring at the Crown Brewery, Kettering, recently, gave me the opportunity of examining certain cores between 170 feet and 290 feet, and below are the pertinent results.

The *Upper Lias* appeared to be 184 ft. 6 in. thick, which included beds at the top described as sandy clays, 11 ft. 3 in. (probably slipped material). The bottom bed was easily identified as the Lower Cephalopoda Bed, the top of the *falcifer* (or *serpentinus*) zone, with the characteristic large specimens of *Ammonites mulgravius*. So the Upper Lias was probably incomplete above and certainly incomplete below, and may well have been another 10 feet thick if complete.

The *Middle Lias* consisted of clay and shales, with only one well-defined hard bed, and in this respect totally unlike south-westerly sections. Fossils were fairly numerous in thin layers at intervals with comparatively unfossiliferous interspaces, which made correlation difficult. I consider that I got small specimens of *Ammonites margaritatus* as low as 246 feet, and *A. capricornus* (also small) at 260 feet, so that the Middle Lias would appear to be between 62 and 76 feet thick. There was no trace of the Marlstone rock-bed, the only hard bed, which apparently is the one that here and there in the neighbourhood has yielded water, was a so-called Sandstone (actually a green, grey, and red rock with black Oolitic granules) 8 inches thick and 11 ft. 3 in. down in the Middle Lias. The Middle Lias beds above this contained minute ammonites, *Avicula inaequivalvis* ?, *Pecten aequivalvis*, and *Pleuromya*.

ORTON.—At the Orton boring the Upper Lias ended, downwards, with the Upper Cephalopoda Bed, the top bed of the *subcarinatus*-zone and so is more incomplete than at Kettering.

The Middle Lias commences with a green, oolitic rock with fossils and pebbles, which, judged by the beds immediately below rather than by its own characters, I classify as " H " of my typical section of the Middle Lias. Supposing this is the equivalent of the hard bed at Kettering, there has here been a greater loss than at Kettering, which the Upper Lias deficiency also suggests, so that 87 feet for the thickness of the Middle Lias, as suggested in previous reports, is probably too much.

DESBOROUGH.—At Desborough the Upper Lias is more nearly complete than at Kettering and Orton, for there was 1 ft. 10 in. of clay below the Lower Cephalopoda Bed and the conglomerate rock constituting the top of the Middle Lias, with broken up fossils, may indeed represent the Marlstone rock-bed, though abundance of *Protocardium truncatum* suggests that, if so, it also includes a residue of a lower bed. Anyhow, the Middle Lias here has suffered denudation.

So there does seem some evidence available to support a theory of "the recurrence of activity along old-established foldings of an early date" in the case of the Charnian anticlinal extension through Northamptonshire, and an indication of one period of its recurrence.

[NOTE.—The Editor being also the author of the original paper, ventures to state that the thicknesses of the Upper Lias here criticized were, with one exception, quoted from Mr. Beeby Thompson's own publication, *The Water Supply of Beds and Northants.*]

The Classification of the Acidaspidae.

BY F. R. COWPER REED, SC.D., F.G.S.

SINCE Dr. J. M. Clarke's[1] attempt in 1890 to subdivide the *Acidaspidae* (= *Odontopleuridae*) by means of the characters of the occipital ring and its spines, several other methods of classification of the members of this family have been proposed. Van Ingen,[2] in 1901, adopted Clarke's names for the subgenera which he raised to the rank of genera, but he slightly modified their definitions and preferred to use the name *Acidaspidae* for the family, as is general in Europe, dividing it into four main groups comprising six genera. Raymond,[3] in 1916, was led to criticize Clarke's principle of classification, pointing out the unnatural association of species which resulted from its application, and he accordingly desired to alter the definitions of the genera as given in 1913 in the second edition of Zittel-Eastman's "Textbook of Palaeontology" (vol. i, p. 722). Special attention was paid to the characters of the pleurae, as in Barrande's old scheme. The genera which he now included in the family, comprised the following, but he recognized that the genus *Odontopleura* could be further subdivided:—

Odontopleura Emmrich.	Type *O. ovata* Emmr.
Acidaspis Murchison.	Type *A. brighti* Murch.
Ceratocephala Warder.	Type *C. goniata* Warder.
Dicranurus Conrad.	Type *D. hamatus* Conr.
Ancyropyge Clarke.	Type *A. romingeri* Clarke.
Selenopeltis Hawle & Corda.	Type *S. buchi* (Barrande).
Glaphurus Raymond.	Type *G. pustulatus* (Walcott).

The last mentioned genus is doubtfully included in the family.

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[1] Clarke, 10*th Ann. Rep. New York State Geol. for* 1890 (1891), p. 61.

[2] Van Ingen, *School of Mines Quarterly* (Columbia Univ.), 1901, No. 1, pp. 34–52.

[3] Raymond, *Ottawa Naturalist*, vol. xxix, 1916, No. 11, pp. 135–9.

The latest and most satisfactory classification of the group is that put forward by Richter[1] in 1917, and it is largely based on the course of the facial sutures and the characters of the pleurae. All his subdivisions are only given subgeneric rank, and are included in the one genus *Acidaspis*. Though his scheme was primarily designed for the Bohemian species it is found to be applicable to the forms from other countries and seems to be more natural than any of those previously proposed. The following are the names which he used for the genera and subgenera of the family:

Genus *Glaphurus* Raymond.
,, *Acidaspis* Murchison.
    Subgenus 1. *Selenopeltis* Corda. Type *A. buchi* Barr.
    ,, 2. *Leonaspis* nov. Type *A. leonhardi* Barr.
    ,, 3. *Primaspis* nov. Type *A. primordialis* Barr.
    ,, 4. *Miraspis* nov. Type *A. mira* Barr.
    ,, 5. *Radiaspis* nov. Type *A. radiata* Goldf.
    ,, 6. *Pseudomonaspis* nov. Type *A. brighti* Murch.
    ,, 7. *Ceratocephala* Warder. Type *A. goniata* Warder.
    ,, 8. *Dicranurus* Conrad. Type *A. hamata* Conr.
    ,, 9. *Ancyropyge* Clarke. Type *A. romingeri* Clarke.

Five new subgeneric divisions and names are seen to be proposed by Richter in this list, and some of the old names are restricted in their meaning. The name *Odontopleura* does not occur and apparently is rejected, but its type-species *O. ovata* Emmrich undoubtedly belongs to *Leonaspis*, and if this is admitted it seems necessary to revive this much disputed name, for it has the priority, Emmrich having proposed it in 1839. It has various North European and American representatives.[2]

Etheridge and Mitchell,[3] who used the name *Ceratocephala* in a generic sense, instituted a new subgenus under the name *Bounyongia* for a new Silurian rather imperfectly known species

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[1] Richter, *Centralbl. f. Miner, etc.*, Jahrg, 1917, Nos. 21 and 22, pp. 462–72, text-figures.

[2] The form figured by Wigand (*Zeitschr. deut. geol. Gesell.*, xl, 1888, p. 99, t. x, figs. 21, 22) as *A.* cf. *ovata* Emmr. does not seem to belong to this subgenus at all, but his *A. mutica* Emmr. is a good example of it. It seems that *A. tuberculata* Conr. (Hall, *Palaeont., New York*, vol. iii, 1861, p. 368, pl. lxxix, figs. 1–14) is a rather peculiar representative of it. Beecher has described the larval form of this species (*Amer. Journ. Sc. Ser.* 3., vol. xlvi, 1893, p. 144, pl. ii, figs. 1–7).

[3] Etheridge & Mitchell, *Proc. Linn. Soc. N.S. Wales*, vol. xlii, 1917, p. 498, pl. xxvi, figs. 12, 13; pl. xxvii, fig. 14.

C. bowningensis Eth. & Mitch., from New South Wales. Raymond[1] has recently separated off under the generic name *Onychaspis* those forms "of the same type as *Ceratocephala*, but in which the free cheeks are not fused to the cranidium".

We may now proceed to examine the grounds and principles on which these classifications and subgenera of the *Acidaspidae* are based. But we may first leave out of account the peculiar genus *Glaphurus* Raymond,[2] which was established for the reception of *Arionellus pustulatus* Walcott, and is clearly without any close genetic or morphological connexion with the other subgenera or genera. Clarke's principle of classification seems artificial, and, as Raymond (op. cit. 1916) pointed out, it is not applicable to the Bohemian species which often possess closely similar glabellar, thoracic, and pygidial characters, though differing in the development of the occipital spines. It does not, therefore, appear to indicate any natural relations, and judging also from the analogy of other tribolites the spinose or non-spinose character of this part of the body is of no evolutionary or genetic importance. Stapff and Reck[3] consider that spines have been developed in *Acidaspis* in connexion with its planktonic life, and Swinnerton[4] likewise regards them; Richter[5] believes that they are designed to retard sinking in the water, as seems especially illustrated in the case of *A. radiata.* We may, therefore, probably regard the spinose processes, not only of the pleurae and pygidium, but also of the head-shield and occipital ring, as being special adaptations to the environment. Moreover, their presence does not show any connexion with the stratigraphical development of the various species of *Acidaspis*.

The course of the facial sutures. the lobation of the glabella, and the degree of fusion of the lobes with one another or with the cheeks are features which seem to be of more structural importance, and Van Ingen and Richter use them to some extent in their schemes. Barrande[6] had long ago proposed a system for grouping the species of *Acidaspis* based on the course of the facial sutures anterior to the eyes and also on the presence of single or double points to the pleurae and the number of segments in the thorax and pygidium; one group which he established consists of those with the anterior branch of the facial suture parallel to the axis and with one point to the thoracic pleurae or with only a feebly developed spine in addition to it developed on the anterior band of the pleurae. This corresponds to Richter's subgenus *Leonaspis*. The other group has the anterior branch of the facial suture inclined to the axis, and the thoracic pleurae possess two points. This group includes Richter's *Primaspis* and *Miraspis*, but the glabella in these subgenera has not an identical lobation.

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[1] Raymond, *Bull. Mus. Comp. Zool. Harvard,* vol. lxvii, No. 1, 1925, p. 129, pl. 8, fig. 13.

[2] Raymond, *Ann. Carnegie Mus.*, vol. iii, 1905, p. 357, pl. xiv, figs. 4–6; ibid., vol. vii, No. 1, 1910, p. 74, pl. xviii, figs. 9–11; id. *Bull. Vermont State Geol. 7th Rept.*, 1910, p. 234, pl. xxxvi, figs. 4–6, pl. xxxviii, figs. 9–11; id. *Bull. Mus. Comp. Zool. Harvard*, vol. lxvii, No. 1, 1925, p. 130.

[3] Stapff and Reck, *Sitz. Gesell. Naturf.*, Berlin, 1911, pp. 130–46.

[4] Swinnerton, GEOL. MAG., Dec. VI, Vol. II, 1915, p. 544.

[5] Richter, *Senckenbergiana*, Bd. i, No. 6, 1919, pp. 234–8.

[6] Barrande. *Syst. Silur. Bohême*, i, pp. 692–707.

Swinnerton (op. cit.) attaches much importance to the lobation of the glabella, and remarks that " the usual stability of the glabella in other families [than the *Acidaspidae* and *Lichadidae*] emphasizes the genetic and classificatory value of the strong tendency towards the breaking up of the glabella into separate lobes shown in these two families ", and he groups them together into a suborder which he terms Odontopleuridae as he considers that they seem to have no connecting links with other suborders.

The lobation of the GLABELLA is indeed one of the chief difficulties in determining their relations, and when we attempt to correlate the individual lobes of some of the subgenera of *Acidaspis* with those of other genera we find it no easy task. In certain subgenera of *Acidaspis* the lobes of the glabella, and the furrows are better and more fully developed than in others, and such is particularly the case with *Miraspis*, of which the type is *A. mira* Barr.[1] and to which belongs also *A. prevosti* Barr.,[2] both occurring in the Silurian Stage E in Bohemia. Barrande[3] has accordingly based his diagram of the cranidium of *Acidaspis* on *A. prevosti*, but in some respects *A. mira* shows certain important features more clearly. In the following remarks it is preferable to use Novak's[4] practice of using the terms first, second, and third in reference to the lateral furrows of the glabella in place of Barrande's " anterior "," middle ", and " posterior ".

The first lateral furrows lie immediately behind the inner (glabellar) ends of the ocular ridges, and from them arise the " false furrows " which run back longitudinally and bound the parallel sided central lobe of the glabella. The second lateral furrows separate the first from the much larger second lateral lobes, and the third lateral furrows divide the latter from the still larger third lateral lobes. According to Barrande and other authors the transverse furrow which bounds posteriorly the central lobe of the glabella corresponds to the occipital furrow in other trilobites, but it is considered to divide on each side into two branches, the " anterior branch " separating the third lateral lobes of the glabella from a pair of basal lobes which are large in *A. prevosti* but smaller in *A. mira*, and are called by Barrande the " occipital lobes ". The supposed " posterior branch " of the occipital furrow is in direct continuation with the " false furrows " and runs straight back, bounding on each side a raised median piece behind the central

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[1] Barrande, op. cit. p. 735, pl. xxxix, figs. 1–11.

[2] Ibid., p. 739, pl. xxxix, figs. 33–41.

[3] Ibid., pl. xxxix, fig. 57.

[4] Novak, *Palaeont. Abhandl.*, Bd. v, heft iii, 1890, p. 33.

lobe which is prolonged back into two free spines and is regarded by Barrande as the median part of the neck-ring, the spines being termed the occipital spines. But below them, at a lower level and connecting the inner ends of the pleuro-occipital furrow behind the cheeks, is another unnamed continuous furrow which separates off a narrow marginal band behind the so-called " occipital lobes ", and this band seems clearly to represent the median (meso-occipital) portion of the true narrow occipital segment, and it corresponds with the pleuro-occipital portions on each side. If we are therefore correct in thus interpreting this unnamed furrow and ring which Barrande does not clearly mention (though he shows them distinctly in one figure of *A. mira*, op. cit., pl. 39, fig. 5, having the paired spines and still more distinctly as a continuous groove and band in another figure, fig. 1, with the spines and median raised piece broken off) it follows that the transverse furrow which he called the " occipital furrow " cannot be so correlated, but must be regarded as homologous with the post-central furrow in *Corydocephalus* and the allied subgenera of *Lichas*. This post-central furrow cuts off a post-central lobe in these members of *Lichas*, and we must therefore regard the raised median piece and its spines in *A. mira* and its allies as belonging to the glabella and not to the occipital ring, and to represent a special development of the post-central lobe.

There arises then the question of the correlation of Barrande's so-called " anterior branches of the occipital furrow " and of his " occipital lobes ". The former are plainly seen in both *A. mira* and *A. prevosti* to lie much more on a level with the post-central furrow than with the pleuro-occipital furrow, while his " occipital lobes " are bounded externally by the posterior part of the axial furrows and the inner angle of the fixed cheek abuts against them. In fact they seem to belong to the glabella and to form a pair of fourth lateral lobes. Indeed they do not seem to have anything to do with the true meso-occipital ring, but lie between the axial furrows and the posterior continuation of the " false furrows " just as do the fourth lateral lobes in the above mentioned subgenera of *Lichas*.

We may doubt therefore if true occipital lobes are present in the subgenus *Miraspis*.

The same structure of the glabella and occipital segment is seen in the typical members of the subgenus *Ceratocephala*, but these four (?) lateral lobes are usually less well defined and circumscribed, and the continuation of the pleuro-occipital and meso-occipital furrows and the distinction of the occipital segment are less clear, owing to the tendency to the fusion of the different parts of the cranidium and to the obsolescence of the furrows on it. However, in the type form, *A. goniata* Warder[1] and in *A. verneuili* Barr.,[2]

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[1] Warder, *Amer. Journ. Sc.*, ser. 1, vol. xxxiv 1838, p. 378, fig. For other references see Raymond, *Bull. Mus. Comp. Zool.*, vol. lx, No. 1, 1916, p. 24.

[2] Barrande, op. cit., p. 710, pl. xxxviii, figs. 1–9.

A. vesiculosa Beyr.,[1] and *A. rara* Barr.,[2] various stages in the modification of the *Miraspis* structure can be recognized. But the foregoing principles of interpretation are undoubtedly applicable, and there is no reason to doubt that the so-called " occipital spines " and " occipital ring " are truly of glabellar origin in all the species of *Ceratocephala*. Etheridge and Mitchell[3] seem to have discovered this fact in the case of the Australian species *Ceratocephala longispina*, for they say that " the ' occipital spines ' are borne by a cowl-like appendage originating at the back of the central glabellar lobe instead of originating in the occipital ring ". But their diagram[4] of the head-shield of *Ceratocephala* hardly gives a correct idea of the subgenus.

There are other subgenera of *Acidaspis* which have further modifications of this type of cranidium. Thus in *Radiaspis* the fourth lateral lobes seem entirely fused with the inner ends of the cheek-rolls, and the same seems to have happened in *Dicranurus*. Both these subgenera have the peculiar bispinose posterior prolongation of the postcentral lobe passing over and behind the true meso-occipital ring.

In the case of *Pseudomonaspis* it is probable that the single stout posterior process is likewise a median development of the post-central lobe and does not belong to the occipital segment, as Richter suggests in the case of *A.* (*Pseudom.*) *bucco* Richter[5] of the Rhenish Devonian, while in *A. grayi* Barr.[6] it seems clearly to pass over the real neck-ring, but no fourth lateral lobes are present.

In the latter respect we thus see a resemblance to the two subgenera *Primaspis* and *Leonaspis*, in which only two or three lateral lobes (i.e. the first, second, and third) are possessed by the glabella, the first being often obsolete and the fourth never developed at all.

Moreover, in *Primaspis* and *Leonaspis* no post-central lobe or furrow is apparently developed, and when spines are developed in the posterior median part of the cranidium they are truly marginal, and do not rise from an elevated median projection lying above a narrow neck ring, but are processes from the real meso-occipital ring. In *Leonaspis* no posterior spines at all are present, but only a median tubercle or spine occurs on the surface of the meso-occipital ring, which is a simple band. The spines on this ring in *Primaspis* may be paired or single ; a median one may only be developed or one or more pairs. But in both of these subgenera the meso-occipital segment does not seem to have been reduced or squeezed out by the hypertrophy of the post-central lobe and its spinose processes.

[1] Ibid., p. 715, pl. xxxviii, figs. 13–21 ; Novak, *Palaeont. Abhandl.*, Bd. v, heft 3, 1890, p. 33, t. ii [xx], fig. 9.

[2] Novak, *Beitr. Palaeont. Oesterr. Ung.*, Bd. iii, 1881, p. 42, t. iii [x], figs. 7–11.

[3] Etheridge and Mitchell, *Proc. Linn. Soc. N.S. Wales*, 1896, pt. iv, p. 717.

[4] Ibid., pl. lv, fig. 2.

[5] Richter, *Jahrb. Nassau Verein. Natur.*, Bd. lxx, 1918, p. 144, text-fig. 1.

[6] Barrande, op. cit., p. 751, pl. xxxix, figs. 20, 21.

The pleuro-occipital and meso-occipital furrows are generally continuous or clearly correspond in all the species of these two subgenera, and there may or may not be small true occipital lobes developed on the neck-ring, as in *Leonaspis pigra* Barr.[1] The same type of glabella is found in both *Primaspis* and *Leonaspis*, two pairs of large lateral lobes being present and a large central lobe more or less marked off on each side by "false furrows", and reaching back to the neck-furrow. The first lateral lobes may or may not be developed, and are always very small, and the two lobes on each side seem to correspond with the second and third lobes in *Miraspis* and *Ceratocephala*. But it seems not improbable that the so-called third lateral lobe is composite and includes the fourth lateral lobe of these subgenera, and that the development of the fourth lateral furrows and post-central furrow are due to a secondary elongation of the glabella and subdivision of its surface, accompanying the later evolution and complication of its structure, for both the subgenera of *Acidaspis* and of *Lichas* which have this similar development of many furrows and lobes belong to the later members of the families. We may, however, regard them in another way as a reversion to the more primitive and distinct segmentation of the head-shield as shown in larval forms before fusion of the separate elements.

But when we consider the stratigraphical distribution of the subgenera of *Acidaspis* we are led to conclude that since *Primaspis* and *Leonaspis* comprise the bulk of the Ordovician species, the comparative simplicity of the glabella and its furrows in them is probably a primitive feature, and that the multiplication of lobes and furrows is a secondary development. On the other hand, there is another concurrent modification which has taken place in the genus simultaneously along a different line, and this has been marked by the loss of furrows and the fusion of lobes, though in *Primaspis* and *Leonaspis* it is rare. In *A. keyserlingi* Barr.[2] we see an example of its occurrence, while in *A. dormitzeri* Barr.[3] and *A. roemeri* Barr.[4] the fusion is less complete; and all these three species must be referred to *Leonaspis*, though they are possible cases of homœomorphy.

Selenopeltis, the earliest known representative of the family, has the lateral furrows of the glabella so broken up and unlike the rest of the subgenera that no exact correlation is possible; but there seem to be four pairs of lateral lobes, and there are undoubtedly no "false furrows" and no cross-furrow which is comparable to the post-central furrow in *Miraspis* and *Ceratocephala*, while posterior spines of meso-occipital origin are absent.

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[1] Novak, *Palaeont. Abhandl.*, Bd. v, heft 3, 1890, p. 31, t. ii (xx), figs. 11–15, t. iv (xxii), fig. 6.

[2] Barrande, op. cit., p. 708, pl. xxxvi, figs. 10–22.

[3] Ibid., p. 728, pl. xxxviii, figs. 22–4.

[4] Ibid., p. 726, pl. xxxix, figs. 29–32.

As regards GENAL SPINES, we may observe certain differences in their place of origin which appear to be important. The usual position is at the posterior lateral angles of the head-shield and in continuation of the marginal border of the free-cheek at its junction with the pleuro-occipital segment as seen in *Primaspis* and *Leonaspis*. But in *Selenopeltis* they appear to arise from the general surface of the cheeks in front of the usual place, and are not marginal, so that we may doubt if they are homologous structures. In *A. mira*, the type of *Miraspis*, the "genal spines" are likewise rather aberrant, being not marginal in origin, for they seem to arise inside it and to be connected with the posterior continuation of the ocular ridge. *A.* (*Ceratocephala*) *rara* Barr.[1] shows the same feature clearly, but in *A.* (*Cerat.*) *vesiculosa* Beyr. this is not so distinct.

The position of the EYES does not seem to be a morphological feature of much value, though it is useful for classificatory purposes. *Ceratocephala* has the eyes subcentral or rather pre-central, their forward position distinguishing the head-shield of this genus from all the others in which they lie nearer the posterior than the anterior margin, except in *Selenopeltis*, where they are equidistant from the margins.

With regard to the course and relations of the FACIAL SUTURES in the members of the genus, we observe that in *Leonaspis* and *Primaspis* the same general course is pursued with a marked angulation and change of direction at the eyes, though in *Leonaspis* the anterior branches are parallel, and in *Primaspis* they are convergent, a distinction to which Richter attaches subgeneric importance. But intermediate stages are found in some species, so that not too much value need be given to this character which is variable in other genera. In *Selenopeltis* the anterior branches are convergent, as well as in *Miraspis*, and apparently so in *Pseudomonaspis*, but the posterior branches in the two last-mentioned are much shorter, and do not make such a sharp angle with the anterior portions. The fusion of the free cheeks with the cranidium is to be regarded as a secondary feature, as Raymond notes.

The THORAX in the different subgenera chiefly differs in the character of the pleurae and in its terminal spines. The number of segments in the thorax affords no guide for the separation of the subgenera, partly owing to our frequent ignorance of complete individuals. The number does not seem to exceed ten.

All the subgenera are described as having pleurae with a narrow median or submedian ridge except *Ceratocephala*, which has the ridge occupying almost the entire surface and a median pleural furrow. A narrow marginal anterior and posterior band is also present in all cases. But in *A. rara* Barr. which belongs to *Ceratocephala* we seem to see a transitional stage, the anterior band being broad and marked off from the narrow submedian ridge by a distinct furrow. There does not, therefore, seem to be any fundamental distinction in the two types of pleurae. It is the median ridge which in *A. rara,* as well as the typical *Primaspis*, *Leonaspis*, *Miraspis*, and *Radiaspis*, which is prolonged into the main free spine which often is not accompanied by any other spines, which is usually the case in *Primaspis.* In *Leonaspis* and *Radiaspis* both the anterior band and median ridge end in spines, while in *Miraspis* a third supplementary spine is present. *Ceratocephala* has only one spine which, as indicated by the species *A. rara,* must be held to belong to the median ridge.

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[1] Novak, *Beitr. Palaeont. Oesterr. Ung.*, Bd. iii, 1881, p. 42, t. x (iii), figs. 7–11.

In *Ancyropyge* and *Dicranurus* we are ignorant of the thoracic characters, while in *Pseudomonaspis* no positive evidence has been brought forward of any part of the body belonging to the type species and the whole subgenus is based on the cranidium.[1]

In *Selenopeltis* the peculiarity of the pleurae lies in the angular bending of the ridge which traverses their surface but does not correspond to any bend or angulation of the margin, though it suggests a fulcrum. The continuation of the ridge into the large free spine, with only a very small free spine at the end of the much reduced and narrow anterior band is conspicuous in the type species, *A. buchi* Barr.

The PYGIDIA do not show such consistent and regular points of distinction in the various subgenera as do the head-shields. Richter, in fact, does not allude to them or figure them in his paper, except to state that *Ancyropyge* is based on and only known by its pygidium. A parallelism of structure or homœomorphy seems to obtain in this member of the body, and adaptation to special conditions has affected it. In all of the subgenera the pleurae of the first axial ring tend to be produced into spines of larger size than those fringing the margin in front of or behind them, and to be the only true pleural spines, the others varying in number and development not only in different species but even in the same species.

In *Selenopeltis* the pygidium differs from all the other subgenera in only having the one pair of pleural spines, no fringing spines being present.

In *Primaspis* and *Leonaspis* there is a variable number of these fringing spines in addition to the one pair of pleural spines, and the axis consists of two or three complete rings. In *Miraspis* no constant difference from this type is apparent. But *Radiaspis* has the second axial ring reduced to a pair of contiguous nodules, and the marginal spines are all equal, no specially large pair of pleural spines being developed. But a similar equal fringe of spines is also found in *A. grayae* Ether.[2] and *A. hystrix* Wyv. Thoms.,[3] with a similar tendency of the second axial segment to become a pair of nodules, though these species are not members of this subgenus, thus illustrating the parallelism of structure in different subgenera above mentioned.

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[1] Lake, *Q.J.G.S.*, vol. lii, 1896, p. 236, pl. vii, fig. 5; Richter, *Jahrb. Nassau Verein. Natur.*, bd. 70, 1918, p. 144.

[2] Reed, *Lower Palaeoz. Trilob. Girvan*, pt. iii, p. 114, pl. xvi, fig. 1.

[3] Ibid., p. 116, pl. xvi, figs. 4, 5.

PROPOSED CLASSIFICATION.

From a consideration of the glabellar and general cranidial characters it appears that the subgenera of *Acidaspis* fall into two main groups, one containing those in which what are here termed the fourth lateral lobes and the postcentral spinose prolongation are developed, and the other in which these structures are absent. To the first group belong Richter's *Miraspis, Ceratocephala, Radiaspis, Dicranurus*, and probably *Pseudomonaspis*, while judging from the resemblance of the pygidium of *Ancyropyge*[1] to that of *Radiaspis* it is probable that it also should be included.

The second group contains Richter's *Primaspis* and *Leonaspis* and Raymond's *Onychaspis*. Probably *Selenopeltis* belongs here also, though in many respects it is rather an isolated form.

Richter (op. cit., p. 463) put *Primaspis* in the first group, but as regards the structure of the glabella and other characters it is certainly a member of the second group and cannot be associated with the *Miraspinae* as he considered.

The definition of the various subgenera (using the type-species in all cases as the guide) may be amplified as follows :—

Miraspis Richter (Type *A. mira* Barr.)[2].—Glabella with fourth lateral lobes always more or less developed ; postcentral lobe produced back into pair of spines. Axial furrows generally incomplete. Cheek-roll well developed. Meso-occipital ring much reduced. Eyes situated far back. Anterior branches of facial sutures convergent ; posterior branches short. Genal spines supra-marginal. Pleurae with median ridge and two to three terminal spines ; anterior and posterior bands present.

Ceratocephala Warder (Type *C. goniata* Warder).[3]—Glabella with fourth lateral lobes always more or less developed ; postcentral lobe produced back into pair of spines. Axial furrows generally obsolescent or incomplete. Meso-occipital ring much reduced. Facial sutures absent, the fixed and free cheeks being fused together. Eyes situated far forward. Genal spines usually connected with ocular ridge. Pleurae with surface occupied almost entirely by broad ridge with weak median groove ; anterior and posterior marginal bands usually narrow ; end of pleural ridge produced into single terminal spine with inferior vertical spine.

(Thorax and pygidium of type species unknown, the above-mentioned characters of thorax being drawn up from allied Bohemian members of the subgenus.)

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[1] Hall and Clarke, *Palaeont. New York*, vol. vii, 1888, p. 71, pl. xvi, B, figs. 15–18.

[2] Barrande, op. cit., p. 735, pl. xxxix, figs. 1–11.

[3] Warder, *Amer. Journ. Sc.*, vol. xxxiv, 1838, p. 377, figure ; Van Ingen, op. cit., 1901, p. 42, pl., figs. 3, 3*a*. Weller, *Bull. No. IV*, pt. ii, *Nat. Hist. Surv. Chicago Acad. Sc.*, 1907, p. 255, pl. xxiii, figs. 1, 2.

The name *Trapelocera* was applied in 1847 by Hawle and Corda to the representative Bohemian species *A. verneuili* Barr. (= *Trap. rhabdophora* H. & C.)

Radiaspis Richter (Type *A. radiata* Goldf.).[1]—Glabella with first three lateral lobes more or less fused together; fourth lateral lobe ill-defined, more or less reduced, and fused with base of cheek-roll (and apparently also with meso-occipital ring) uniting below posterior forked prolongation of postcentral lobe. Facial sutures with anterior branches convergent. Eyes situated far back. Pleurae with median ridge produced into spine and with terminal spine on anterior band. Pygidium with second axial ring represented by pair of nodules; marginal fringe of many equal radiating spines.

Dicranurus Conrad (Type *D. hamatus* Conr.).[2]—Glabella with one long composite lateral lobe on each side. Fourth lateral lobes much reduced, nearly obsolete. Cheek-roll fused at base with thickened meso-occipital (?) ring passing below posterior prolongation of post-central lobe which is produced behind into pair of long spirally curved or sharply bent processes. Eye situated rather far back.

Pseudomonaspis Richter (Type *A. brighti* Murch.).[3]—Glabella with two pairs of well-defined lateral lobes on each side of central lobe; fourth lateral lobes obsolete or nearly so. Postcentral lobe produced back into stout single median process, with thickened meso-occipital (?) ring passing below it.

Leonaspis Richter (Type *A. leonhardi* Barr.).[4]—Glabella with two or three pairs of lateral lobes occasionally more or less fused, but no fourth lateral lobes. Axial furrows complete. No postcentral lobe or processes. Meso-occipital ring well developed, without marginal spines. Eyes situated far back. Facial sutures with anterior branches parallel and posterior branches diverging widely. Genal spines normal, at genal angles. Pleurae with median ridge produced into spine; anterior marginal band with or without spine. Pygidium with several pairs of marginal spines, the one connected with first axial ring usually longer and stouter than rest. [The generic division *Odontopleura* Emmrich, 1839, type *O. ovata* Emmrich, seems to be identical.]

Primaspis Richter (Type *A. primordialis* Barr.).[5]—Glabella with two or three pairs of lateral lobes, but no fourth lateral lobes. Axial furrows complete. Postcentral lobe and processes absent.

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[1] Goldfuss, *Jahrb.*, 1843, heft v, p. 544, pl. iv, fig. 1. Richter, *Centralbl. f. Miner. Geol. Jahrg*, 1917, p. 468, text-figs. 9*a*–*c*, 10.

[2] Conrad, *5th Ann. Rept. New York*, 1841, p. 48; Hall, *Palaeont. New York*, vol. iii, 1861, p. 371, pl. lxxix, figs. 15–19; Clarke, *10th Ann. Rept. New York State Geol.*, 1891, pl. i, figs. 5, 6; Van Ingen, op. cit., 1901, p. 37, text-fig. 7.

[3] Murchison, *Silur. Syst.*, 1839, p. 658, pl. xiv, fig. 15; Lake, op. cit., p. 236, pl. vii, fig. 5.

[4] Barrande, op. cit., p. 720, pl. xxxvii, figs. 1–11.

[5] Ibid., p. 707, pl. xxxvii, figs. 14–17.

Meso-occipital ring well developed, with two or more marginal spines. Eyes rather far back. Facial sutures with anterior branches convergent, posterior branches widely divergent. Pleurae with median ridge produced into spine and anterior and posterior marginal bands also furnished with small terminal spines. Pygidium of same type as *Leonaspis.*

Selenopeltis Hawle and Corda [1] (Type *A. buchi* Barr.).[2]—Glabella with indistinct number of lateral lobes more or less fused together on each side. Axial furrows complete. Meso-occipital ring simple, broad, without marginal spines. Eyes subcentral. Genal spines arising above and inside genal angles. Cranidial margin without spines. Facial sutures well developed, angulated at eyes. Pleurae with diagonal median ridge arched strongly back at tip and produced into long spine ; anterior band with small terminal spine. Pygidium with one pair of spines connected with first axial ring. [Clarke (op. cit.) is incorrect in stating that the pygidium is spineless.]

Bounyongia Etheridge and Mitchell (Type *A. bowningensis* Eth. and Mitch.).[3]—Glabella with pair of cephalic spines originating on the glabella in front of the neck-ring (otherwise glabella and lobes are stated to resemble "*Ceratocephala*" *longispina* Mitchell) [4], but there seems to be a true continuous occipital segment, no "occipital" (fourth lateral) lobes, and no prolongation of the post-central lobe into spines above and behind the meso-occipital ring as in *C. longispina,* which probably is itself referable to *Dicranurus.*

Onychaspis Raymond [5] (Type *O. confraga* Raymond, Holston Formation, Middle Ordovician, Viginia). Gladbella with three pairs of lateral furrows. No fourth lobes. Axial furrows obsolete. Meso-occipital ring large, with median tubercle and pair of large posterior spines. Eyes subcentral.

Amongst the British species of *Acidaspis* we find at least five of the above subgenera represented, but of the occurrence of *Selenopeltis* there is some doubt, and *Miraspis, Dicranurus, Ancyropyge* seem completely absent. The distribution of the species is as follows :—

Ceratocephala	*A. barrandei* Fletch. and Salt.
	A. terribilis Reed.
	A. crenata Emmr.
Radiaspis	*A. robertsi* Whidb.
	A. pilata Whidb.
Pseudomonaspis	*A. brighti* Murch.
Leonaspis	*A. coronata* Salt.

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[1] Hawle and Corda, *Prodr. Mon. Böhm. Trilob.*, 1847, p. 34, t. i, fig. 1.

[2] Barrande, op. cit., p. 716, pl. xxxvi, figs. 1–9, pl. xxxvii, figs. 25–7.

[3] Etheridge and Mitchell, *Proc. Linn. Soc., N.S.W.*, vol. xlii, pt. iii, 1917, p. 498, pl. xxvi, figs. 12, 13 ; pl. xxvii, fig. 14.

[4] Etheridge and Mitchell, *Proc. Linn. Soc., N.S.W.*, pt. iv, 1896, p. 715, pl. liii, fig. 10 ; pl. liv, figs. 1-5.

[5] Raymond, *Bull. Mus. Comp. Zool. Harvard*, vol. xlvii, No. 1, 1925, p. 129, pl. 8, fig. 13.

Leonaspis	*A. deflexa* Lake.
	A. erinacea Marr and Nich.
	A. asteroidea Reed.
	A. girvanensis Reed.
	A. semievoluta Reed.
	? *A. callipareos* Wyv. Thoms.
	? *A. convexa* Reed.
Primaspis	*A. quinquespinosa* Salt.
	A. caractaci Salt.
	A. hughesi Salt.
	A. grayae Eth.
	A. hystrix Wyv. Thoms.
	A. lalage Wyv. Thoms.
	A. playfairi Reed.
	A. turnbulli Reed.
	A. sladensis Reed.
	? *A. dalecarlica* Tornq. ?
	? *A. biserialis* Salt.

(It is probable that some of these species placed in *Primaspis* should be transferred to Raymond's newly formed subgenus *Onychaspis*.)

Woodward in his Catalogue in 1877, gave the names of fourteen British species, but two of these were only MS. names and the form called *A. unica* belongs to the genus *Nieszkowskia* as mentioned elsewhere by the author.[1]

There are some other doubtful species which have never been adequately defined, such as *A. dama* Fletch. and Salt. and *A. dumetosus* Salt. mentioned by Lake (op. cit., p. 243), and the occurrence of *A. buchi* in the British Isles rests on the doubtful identification of some poor specimens in the Sedgwick Museum from the Arenig of South Wales.

With regard to *A. jamesi* Salt. it cannot be placed with *Ceratocephala*, because it has well-developed facial sutures and ridged pleurae. The eyes are, however, nearly as far forward as in that subgenus, and it thereby differs from *Miraspis*. The pleurae also only have one point, whereas in *Miraspis* there are two to three spines. No trace of the narrow marginal true meso-occipital ring is visible beneath the paired posterior median spines, and there is no post-central furrow. Probably it belongs to *Onychaspis*.

A. crenata Emmr. is said by Lake (op. cit., p. 240) to be only distinguishable from *A. barrandei* by the presence of a pair of tubercles on each ring of the axis and on each pleura.

In the case of *A. bispinosus* McCoy, the oval shape of the central lobe is peculiar; the two well-defined oval lateral lobes on each side, narrow definite cheek roll and the absence of any fourth lateral lobes separate it from *Ceratocephala*, as does also the development of facial sutures, although the shape of the head-shield, the position of the eyes, the pair of posterior median spines with the meso-occipital ring passing below their base recall its structure and characters. We may put this species also in *Onychaspis.*

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[1] Reed, *Low. Pal. Trilob. Girvan*, pt. iii, p. 142.

A. quinquespinosa was put by Richter in *Pseudomonaspis,* but it must be transferred to *Primaspis,* because it has not the posterior median process of the former, but several marginal spines, on the meso- and pleura-occipital rings. This species well shows (see Lake, op. cit., pl. vii, fig. 4) the true occipital furrow continuously marking off the occipital segment.

STRATIGRAPHICAL DISTRIBUTION OF THE SUBGENERA.

Selenopeltis appears to be the oldest subgenus and to be known only from the Lower Ordovician, and not to occur out of Europe.

Miraspis seems confined to the Silurian and does not at present seem to have been recognized out of Bohemia.

Ceratocephala is widespread, but occurs chiefly in the Silurian and Lower Devonian of Europe, America, and Australia (*C. vogdesi* Eth. and Mitch.[1]) though it seems to appear in the uppermost Ordovician in Scotland.

Pseudomonaspis is only known to contain two Silurian and one Devonian species, and has not been found outside Europe.

Primaspis and *Leonaspis* are found not only in the Ordovician and Silurian, but also in the Devonian (e.g., *A. callicera* Hall [2] and probably *A. robinia* Clarke [3]). They are known from Europe, America, and Australia (e.g., *Odontopleura jenkinsi* Eth. and Mitch.) [4]

Onychaspis appears to be limited to the Ordovician.

Dicranurus, *Radiaspis*, and *Ancyropyge* are exclusively Devonian subgenera. The last is only known in America, and the second only in Europe.

ADDENDUM.

Since the above notes were written it has been found that Rud. and E. Richter (*Unterlagen zum Fossilium Catalogus*, Trilobita II, "Senckenbergiana," Bd. vii, Heft 3/4, 20th April, 1925) have adopted the name *Ceratocephalidae* for the family, on the basis of Warder's generic name *Ceratocephala*, 1838 (genotype *C. goniata* Warder, 1838), which has strict priority over the better known and more generally accepted name *Acidaspis* Murchison, 1839. Elsa Warburg, however ("Trilobites of the Leptaena Limestone in Dalarne," *Geol. Bull. Instit. of Upsala*, vol. xvii, 1925, pp. 233–54 (reprint)) retains the family name *Acidaspidae* Barrande, and discusses Raymond and Richters' classifications, neither of which are considered altogether satisfactory, for the Swedish species do not seem to fit into any of the groups. The validity of Richters' groups is criticized, but it is considered "inappropriate under the circumstances to introduce any new subgeneric or generic terms or to attempt any closer appraisement of the ranks of the groups." For these reasons Warburg regards it as best to refer all the species from the Leptaena Limestone to the same genus, for which "the most commonly accepted generic term *Acidaspis*" is used.

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[1] Etheridge and Mitchell, op. cit., pt. iv, 1896, p. 707, pl. l, figs. 8, 9; pl. li, figs. 1–7; pl. liii, fig. 9.

[2] Hall and Clarke, *Palaeont. New York*, vii, 1888, p. 69, pl. xviB, figs. 1–13.

[3] Clarke, *Bull.* 107 *New York State Mus.*, 1907, p. 171, text-figs.

[4] Etheridge and Mitchell, op. cit., p. 705, pl. lii, figs. 6, 7; pl. liii, figs. 4–7.

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June, 1925.

REVIEWS.

Radioactivity and the Surface History of the Earth: Being the Halley Lecture delivered on 28th May, 1924. By John Joly, Sc.D., F.R.S. pp. 40, with one coloured map and 8 text-figures. Oxford: Clarendon Press, 1924. Price 4*s*. net.

THIS is an interesting theory and is ably expounded. By the theory of isostasy the continents may be likened to a sheet of ice on water; the peaks on the surface demand a bulge underneath in order to support their weight. Thus the continental crust is thicker under mountains than elsewhere. This thickening is caused by lateral pressure of the sea-floor on the continents during periods of solidification of the magma ocean of the underworld. As the draft of the continents is six and a half times their freeboard, what we can see of mountain-ranges must be a very small part of what they are. And any calculations of the lateral forces during periods of mountain building which are based on surface crumpling, etc., must fall far short of the forces required by this theory. The workings of isostasy would be seen at their best when the temperature of the surface of the earth was at the melting point of basalt. The continents would then float properly and as the basalt solidified they would roughly retain their position like pieces of fruit in a cooling jelly. Hereafter, melting and solidification of the magma ocean would cause a rising and falling of the continents as the author describes. Radioactivity is given as the cause of this melting. If there were other sources the period between successive revolutions would be decreased. Also are we to understand that radioactivity is confined to the outer few hundred miles of the earth's crust? Surely this is curious and if true must have some meaning. We should like to have some idea of the decrease of radioactivity since the crust was formed: presumably it must have decreased somewhat.

The seas are the largest surface features of the earth; the mountains are small in comparison. But while the mountains are nicely explained by this theory, the absence of acidic crust where the seas now are is not explained. We agree with the lecturer that the thickness of the continental crust is determined by his theory.

If the thickness of the continental crust is the theoretical one then the sum of the areas of the continents can be found when we know the amount of acidic crust, i.e. the amount of magmatic differentiation, that has occurred. Spread the acidic crust uniformly over the earth's surface and its thickness will be less than the theoretical; why should magmatic differentiation have stopped before reaching its limit ? and supposing it did, why should the acidic crust have fled from very large parts of the earth's surface and piled itself to its theoretical thickness over the remainder ? Surely we should have uniform crust covered with a shallow sea. Splits would form as required by this theory, and possibly make deeper parts of the sea, but these would be long thin deeps and not huge areas.

The lecture is well illustrated with figures, but a little more explanation of the maps might have been given.

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CORRESPONDENCE.

AMMONITES FROM THE SHENLEY LIMESTONE.

Sir,—From Dr. Spath's letter in your last number it appears that Dr. Kitchin and Mr. Pringle still refuse to credit any evidence telling against their opinion as to the stratigraphical position of the Shenley limestone.

I dealt fully and fairly with this opinion, showing it to be erroneous, in my paper on the sections around Leighton Buzzard published in *Quart. Journ. Geol. Soc.*, vol. 78 (1922), wherein the facts respecting the ammonites now in question were incidentally stated (p. 47). I need not reiterate the statement on this point or the general argument, but will take the opportunity to mention that I have continued to keep the sections under observation, and that all the new facts disclosed during the last three years through the enlargement of some of the pits and the opening of others have been consonant in every respect with my former descriptions and conclusions.

At present the southern part of the crucial section in Harris's pit is exceptionally well displayed, and reveals some small lenticles of the concretionary fossiliferous limestone in place among the iron-grit breccia. A big new pit has been opened on the western side of the road just north of Miletree Farm, exposing a good section resembling that of the old pit east of the road, now disused and obscure. To any geologist acquainted with the prevalent characters of the base of the Gault, a careful examination of these two sections, with a glance at those of the pits lying between them, will be more convincing than any verbal argument or description can be. But the visit should be made in dry weather, as the guttering of the superincumbent Gault renders the sections obscure and difficult of access after rain.

The attitude adopted by Dr. Kitchin and Mr. Pringle in this matter is exemplified throughout their letter in the GEOLOGICAL MAGAZINE for June, 1922, and especially by their treatment therein of the evidence from Long Crendon, a place 17 miles south-west of Leighton. I have not cared hitherto to reply to this letter, but will now briefly re-state the facts as regards Long Crendon.

The late A. J. Jukes-Browne described in his Gault Memoir (*Geological Survey*) a section seen by him at this place in 1885, showing Gault clay overlying a thin ferruginous pebbly bed containing in places " lumps of calcareous stone ". This bed was classed by him as " Lower Greensand ", and therefore was not further dealt with in his Gault Memoir. In the same year the Survey Fossil-collector (Mr. J. Rhodes) visited the locality, and collected some fossils in gritty calcareous stone, which he registered as from " Lower Greensand ", of course following Jukes-Browne's classification. This was 17 years before I found the same kind of calcareous stone with the same kind of fossils in the same stratigraphical position at Shenley, and I was then unaware of the previous discovery. It was indeed not until 1920, when the Long Crendon fossils were overhauled at my request, that the similarity of the material from the two localities was recognized. Because of this similarity Dr. Kitchin and Mr. Pringle, in spite of the Survey Register and the history of the discovery, refuse to believe that the fossils came from below the Gault, and actually say in their letter—" In reality there is no particle of evidence for that belief." They substitute a hypothetical explanation—" We have no doubt that the fossils . . . came from the surface," and suggest that they may have occurred in a small boulder of " red chalk ". But there is no red chalk known in England which would yield this assemblage of fossils, and the " drift " in the locality is confined to a sprinkling of flints in the soil, with not the least likelihood that a small boulder of any kind of limestone could have persisted at or near the surface.

Surely, disservice is done to palaeontological science by this attitude. How can the true range and phylogeny of the fossils be worked out if the palaeontologist closes his book against facts new to his unavoidably limited knowledge of past life ?

G. W. LAMPLUGH.

ST. ALBANS.
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